GOOD PRACTICE GUIDE 170

Reducing Water Pumping Costs in the Steel Industry

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

GOOD PRACTICE GUIDE 170

REDUCING WATER PUMPING COSTS IN THE STEEL INDUSTRY

This booklet is No. 170 in the Good Practice Guide series and is aimed at those who are seriously concerned about how to reduce the costs of water pumping in the Steel Industry. The Guide describes the various types of water pumping systems in use in the Steel Industry and the problems associated with them. The Guide also describes the opportunities that are available to make energy savings and gives examples and case histories showing how this might be achieved. An Action Plan is included to help those who wish to reduce the operating costs of water pumping systems.

Prepared for the Department of the Environment by:

ETSU
Harwell
Didcot
Oxfordshire
OX11 0RA

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(Fig Nos 28, 29 and 30 by courtesy of Weir Pumps Ltd)

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FOREWORD

This Guide is part of a series produced by the Government under the Energy Efficiency Best Practice Programme. The aim of the programme is to advance and spread good practice in energy efficiency by providing independent, authoritative advice and information on good energy efficiency practices. Best Practice is a collaborative programme targeted towards energy users and decision makers in industry, the commercial and public sectors, and building sectors including housing. It comprises four inter-related elements identified by colour-coded strips for easy reference:

— *Energy Consumption Guides:* (blue) energy consumption data to enable users to establish their relative energy efficiency performance;

— *Good Practice Guides:* (red) and *Case Studies:* (mustard) independent information on proven energy-saving measures and techniques and what they are achieving;

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ENGLAND

London
Govt Office for London
6th Floor
Riverwalk House
157-161 Millbank
London
SW1P 4RR
Tel 020 7217 3435

East Midlands
The Sustainable Development Team
Govt Office for the East Midlands
The Belgrave Centre
Stanley Place
Talbot Street
Nottingham
NG1 5GG
Tel 0115 971 2476

North East
Sustainability and Environment Team
Govt Office for the North East
Wellbar House
Gallowgate
Newcastle-upon-Tyne
NE1 4TD
Tel 0191 202 3614

North West
Environment Team
Govt Office for the North West
Cunard Building
Pier Head
Water Street
Liverpool
L3 1QB
Tel 0151 224 6401

South East
Sustainable Development Team
Govt Office for the South East
Bridge House
1 Walnut Tree Close
Guildford
Surrey
GU1 4GA
Tel 01483 882532

East
Sustainable Development Awareness Team
Govt Office for the East of England
Heron House
49-53 Goldington Road
Bedford
MK40 3LL
Tel 01234 796194

South West
Environment and Energy Management Team
Govt Office for the South West
The Pithay
Bristol
Avon
BS1 2PB
Tel 0117 900 1700

West Midlands
Regional Sustainability Team
77 Paradise Circus
Queensway
Birmingham
B1 2DT
Tel 0121 212 5300

Yorkshire and the Humber
Sustainable Development Unit
Govt Office for Yorks and the Humber
PO Box 213
City House
New Station Street
Leeds
LS1 4US
Tel 0113 283 6376

NORTHERN IRELAND
IRTU Scientific Services
17 Antrim Road
Lisburn
Co Antrim
BT28 3AL
Tel 028 9262 3000

SCOTLAND
Energy Efficiency Office
Enterprise and Lifelong Learning Dept
2nd Floor
Meridian Court
5 Cadogan Street
Glasgow
G2 6AT
Tel 0141 242 5835

WALES
Business and Environment Branch
National Assembly for Wales
Cathays Park
Cardiff
CF10 3NQ
Tel 029 2082 5172

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1. INTRODUCTION

1.1 Pumping Costs

Electricity consumed by British industry for pumping fluids has been estimated to cost more than £1,000 million/year. The steel industry is a relatively small contributor to this total (a crude estimate suggests approximately 3%). Nevertheless, in view of the high specific energy costs in the steel industry (12-15% of the total costs) it is essential that all aspects of energy use should be examined. The significance of water pumping can be gauged by the following facts:

- British Steel, for example, uses more than 400 water pumps with a power rating of at least 100 kW;

- up to 500 tonnes of water are pumped at steelworks for each tonne of steel produced;

- the cost of electricity for water pumping accounts for around £2/t of steel produced.

Energy costs are expected to continue rising.

1.2 Water Costs

Freshwater from reservoirs, rivers, canals, boreholes, etc is introduced into steel industry water systems either for immediate use, or to replace lost or discarded water from recirculating systems. Various grades of water are used and its cost reflects the quality. The total cost of freshwater to the steel industry is in excess of £10 million/year. When no longer fit for its purpose, used water is discarded. Disposal costs amount to more than £2 million/year. The charges for freshwater and disposal are rising rapidly and therefore the cost to the steel industry will escalate if present levels of usage are maintained.

1.3 Environmental Pressures

If the electricity consumed by steel industry pumps were provided solely by coal-fired power stations it would require approximately 450,000 tonnes of coal to be burnt each year.

Up to 100 million m^3/year of freshwater is used for replenishing pumping systems, representing a considerable burden on an increasingly valuable natural resource. Discarded water is usually dumped to river or sea, but could contain a number of contaminants, such as oil and metals. Pressure from environmental bodies to reduce both water use and disposal is expected to increase.

1.4 Savings Potential

Water pumping is a topic which has received relatively minor attention and it is considered that substantial savings may be achievable, not only in the steel industry but in other industries employing pumping systems. Based on investigations within British Steel the savings potential has been estimated to be at least 10% of the total running costs, but could be greater than 20%. This would be worth in excess of £6 million/year to the steel industry. The mechanisms for achieving such savings are based mainly on matching pumping equipment and its operation with process requirements. In some instances this requires elaborate solutions incorporating improved technology, although much could be achieved by simpler and less costly measures.

1.5 Why Aren't Widespread Savings Being Made?

Unfortunately, many opportunities for reducing pumping costs are not recognised. The reasons for this include the following:

- the basic principles of pumping are often misunderstood;
- provided pumps are running and delivering sufficient water they are considered to be functioning satisfactorily;
- production concerns outweigh pumping considerations;
- there is a lack of awareness of pumping costs;
- life cycle costs (i.e. initial costs plus running and maintenance costs) are rarely considered at the design stage.

1.6 How Can This Guide Help?

To help address some of these issues this Guide provides information on:

- basic operating principles of water pumps used in the steel industry;
- typical pumping systems;
- typical problems encountered;
- possible solutions to problems;
- case studies;
- an ACTION PLAN aimed at reducing operating cost.

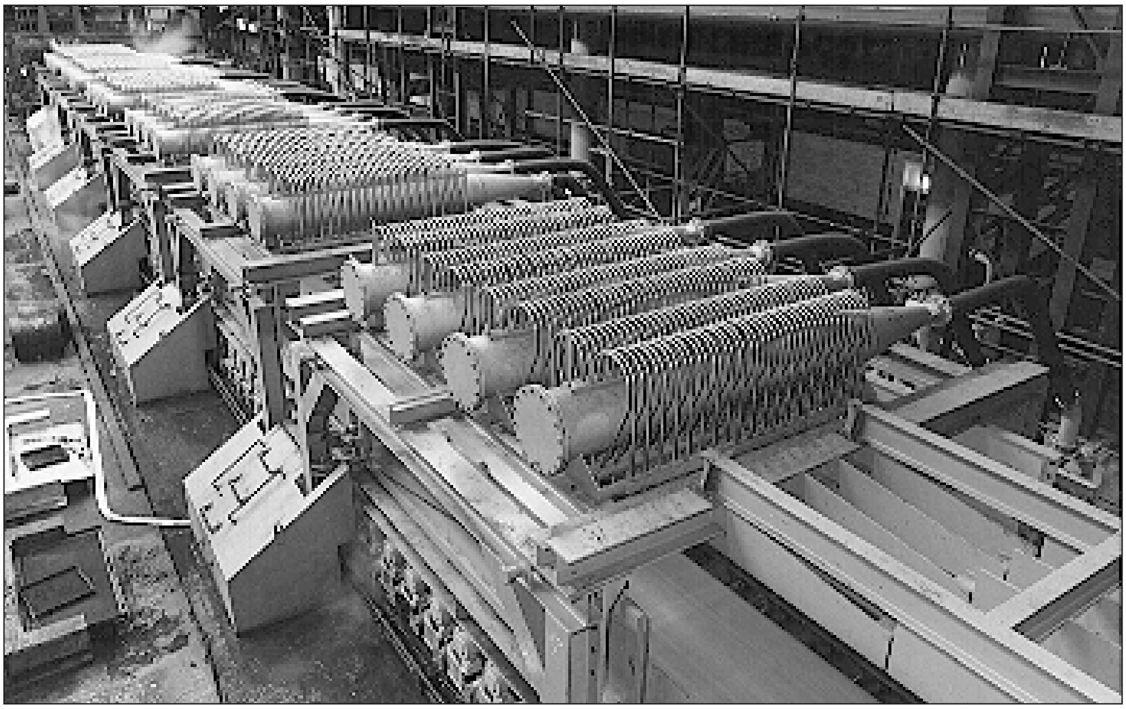

Fig 1 Typical water pump in action in the steel industry

2. WATER PUMPING PRINCIPLES

2.1 Pump Running Costs

An example using a pump typical of those found in the steel industry can help to illustrate pump running costs.

Example: A pump delivers 560 m^3/h into a 55 m head with 86% efficiency, and is driven by a motor with 95% efficiency. For a typical average industrial electricity cost of 3.5 p/kWh, how much does it cost to run the pump continuously for a full year?

560 m^3/h = 156 l/s

Power absorbed $= \dfrac{156 \text{ l/s} \times 9.81 \text{ m/s}^2 \times 55 \text{ m}}{0.86 \times 1000}$

= 98 kW (approx.)

$\therefore$ Motor input power $\dfrac{98}{0.95}$ = 103 kW

$\therefore$ Annual running cost = 103 kW x 24 h x 7 day x 52 weeks x £0.035/kWh

= £31,500

For comparison, if the pump were run through a 15 shift working week for 48 weeks only, the running costs would be:

103 kW x 8 h x 15 shift x 48 weeks x £0.035/kWh = £20,800 (approx.)
or 33% less

Therefore, in general terms, a 100 kW pump costs between £20,000 and £30,000/year to run.

2.1.1 *Pump and Motor Purchase Costs*

For the pump used in the above example the approximate purchase costs to an industrial purchaser are as follows (1994 figures).

Bare shaft pump alone	£6,500
or	
Pump + motor	£10,000

Comparing this with the running costs it can be seen that the capital cost for a new pump plus motor is consumed in a period of between four months and six months.

2.1.2 *Lifetime Costs*

Various figures have been quoted for the lifetime costs of a pump, but in general they suggest that for a pump lifetime of, say, 20 years the costs as percentages of the total are thus:

Initial capital cost of pump + motor	2.5%
Maintenance costs	2.5%
Running Costs	**95%**

The main conclusion to be drawn from these figures is that running costs far outweigh capital costs and should be considered far more important when specifying new equipment. Pumps and motors should be sized according to short-term requirements. If they are oversized to cater for potential increases in water demand, then running costs, as well as capital cost, will be

elevated. The extra costs incurred may be greater than the cost of replacing pumps should the need for greater pumping capacity arise. Furthermore, it has been said that an increase of just 1% in pumping efficiency would reduce the UK pumping bill by £20 million/year. Therefore, it is important to maintain pump operation at high efficiencies, and to minimise ineffective pumping. In general, pumps and their operation should be well matched to the water requirements of the process.

3. STEEL INDUSTRY WATER PUMPING SYSTEMS

The main uses of water in the steel industry are for cooling, descaling, washing, flushing etc, but the predominant use is for cooling, e.g. rolling mill rolls, water cooled elements, product cooling, steam condensers and gas quenching. Pumping systems vary enormously in their complexity, but the following types of recirculating system are used as examples to illustrate in general terms the main features encountered. Pump types are described in Appendix 2.

3.1 Open-circuit Systems

This type of system is typical of those found at rolling mills for providing roll-cooling water. A schematic diagram of such a system is shown in Fig 2.

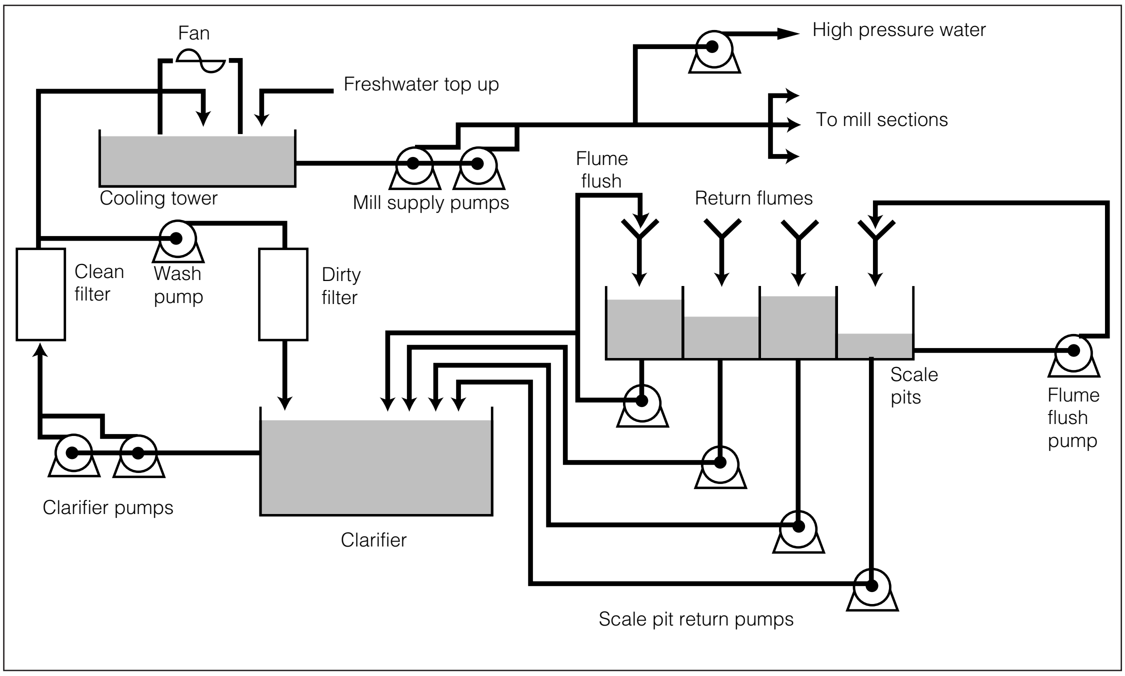

Fig 2 Schematic of an example open-circuit water system

Mill supply pumps provide the main supply of water to the various parts of the mill for roll-cooling. A booster pump might be included as part of the system to provide high pressure water for descaling. All of the water used on the mill drains via flumes into collection ponds or scale-pits for coarse screening of particulates such as mill scale. Some of the collected water can be pumped back through the flumes by dedicated flushing pumps to help shift scale. Most of the water is returned to a water treatment plant using scale-pit return pumps, although a portion of the output from these pumps might also be used to aid flume flushing. Returned water may be collected in a large settling pond or clarifier which allows any returned particulates to settle out under gravity. Clarifier pumps send clarified water through a fine filter to a cooling tower which acts as the supply pump sump. At times, fan power may be used to assist cooling. Any lost water can be replaced from a freshwater top-up supply at the cooling tower. Periodically, the filter may be switched out of circuit for back flushing.

In this type of system it can be seen that water must be pumped a minimum of three times each time it is used, although with six sets of pumps involved, and some of these recirculating water around small loops within the main circuit, some water may be pumped several times more. Consequently, the system demands a lot of pumping energy and the circulation of water has control implications for the pumping equipment.

3.2 Closed-circuit Systems

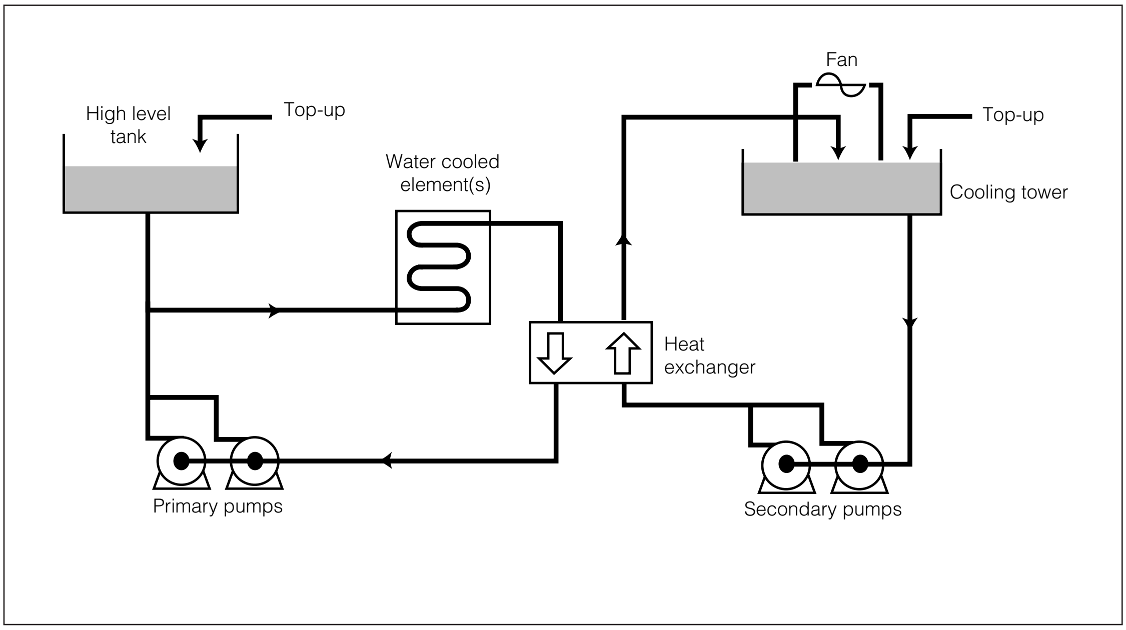

Fig 3 Schematic of an example closed-circuit water system

This type of pumping system is somewhat simpler than the open-circuit type. It usually consists of two separate water circuits, as shown in Fig 3, a primary system and a secondary system. The primary system has a set of supply pumps which feed one or more water cooled elements, e.g. electric arc furnace panels or a reheating furnace water cooled beam. Before returning to the pump inlet the water must lose heat and this is achieved by passing through a heat exchanger linking the primary and secondary circuits. Secondary pumps supply cooled water to the heat exchanger. Heat gained there is given up at a cooling tower so that the cooled water supply is maintained. A freshwater top-up replaces any water lost through spillage or evaporation.

Even in this much simpler type of system two pump sets are required, and possibly some fan power.

3.3 Descaling Systems

On many steelworks, high pressure descaling systems are used to remove scale from reheated steel. The high pressure and high flow requirements lead to high energy use, especially where wide materials are processed. Such systems can comprise a large pump (possibly a *multi-stage* device), supplying water to one or more sets of descaling headers. Each header can be fitted with an array of nozzles to direct water jets at the steel surfaces. Between descaling operations water is diverted away from the headers and directed to a collection flume by using hydraulic switching valves. In some instances, the short duration water demand during each descale operation exceeds the pump capability. Air-sprung accumulators are then employed to augment the flow and are refilled between descale operations.

Descaling systems are worthy of mention here, mainly because of their high energy use, though their design and operation are somewhat specialised and are largely beyond the scope of this Guide. However, many of the general principles discussed in the following Sections are applicable.

4. TYPICAL PROBLEMS ASSOCIATED WITH STEEL INDUSTRY PUMPING

4.1 Excessive Water Use

In many cases, cooling systems provide water to water cooled elements which have been manufactured by another company. The manufacturer states the water requirements based on physical tests or theoretical calculations, but will no doubt have added some extra quantity as a safety margin. When designing a water system to supply such elements, the specified water requirement will be regarded as the minimum requirement. Therefore, the system is designed to supply at least this amount on a continuous basis. In this way, pumping systems become over-designed from the outset. This can lead to the installation of larger than necessary pumps and pipework.

Some water cooling duties are difficult to specify, e.g. roll-cooling. In such cases there is a tendency to supply plenty of water. Provided no shortage of water is recognised, the supply is regarded as satisfactory. Roll-cooling systems often suffer from poorly designed water delivery, through crudely fashioned pipes, directing water with excessive velocity, not necessarily to the most appropriate part of the rolls. In many cases, improved cooling could be achieved with less water. Despite this, it is common for mill operators to demand more water, rather than make better use of what they have.

Many pumping systems in the steel industry have been in operation for more than 20 years. Modifications to either the process, the throughput, or the system may have changed the water demands, with pumps being expected to cope with completely different circumstances from the initial specifications, resulting in inefficient operation.

In summary, the quantities of water being pumped may not be the true requirements of the items being cooled. Excessive pumping increases costs, and operation at high efficiencies may not be possible because of system changes or over-design.

4.2 Unnecessary Water Use

It is unlikely that all water-cooled equipment requires cooling at all times. There may be exceptions, such as furnace components (where some cooling is necessary while the furnace remains hot), but many items are part of intermittent processes. For example, a rolling mill might roll steel for only 70% of the available time each week. During the remaining time the plant is stopped for either planned or unplanned reasons. Even under production conditions some items of plant might be omitted from the production route and need no cooling. For example, parts of the finishing mill might not be used when rolling products with a large finished size, or different materials might require more cooling than others. Also, there are many steel plants which do not produce at weekends.

The water demands of steelworks processes are variable and intermittent but this is often not recognised as far as water pumping systems are concerned. They are set to satisfy maximum demand and left running at that setting. Some pumps run at weekends, just because a small furnace item requires cooling.

4.3 Wasteful Recirculation

At times when items of plant are not in use and do not require cooling water, their supply is often diverted, usually straight to the collection flume. In such circumstances water is merely being recirculated having served no useful purpose. Some diversion pipes include restrictions which help to reduce the diverted flow and hence the pumping power being used. Other divert routes are deliberately contrived to maintain water pressure by diverting full flow straight to the flume.

4.4 Multiple Pump Sets Multiplying Problems

Several sets of pumps can be involved in recirculating water, especially in open-circuit systems. Therefore, excessive amounts of water distributed by supply pumps require extra energy from other pumps in the system to recirculate the excess. Extravagant or unnecessary water use elevates the pumping costs at all the pumps within the recirculating system.

4.5 Wasteful Balancing of Systems

The complexity of typical open-circuit water systems favours simple operation based on static control, i.e. it is easiest for the operators to set up the systems so that the supply pumps deliver sufficient water to meet maximum demand at all times, whether required or not, and to arrange for all return pumps to cope with this quantity. In this way a static balance can be achieved which always satisfies the process demands, but wastes energy.

4.6 Oversized Pumps

Not only water requirements can be over-designed, the pumps selected to supply the water can also be over-designed. It is common practice to add approximately 10% to the estimated frictional losses of a pipework system design, then to specify pumps based on the elevated figure, resulting in oversized pumps. This practice has developed to allow for any fall-off in pump efficiency through wear, and to allow for any pipework fouling which may occur as the system ages. However, oversized pumps cost more to purchase, and because they are not operated at their peak efficiency flow they also cost more to run.

4.7 Inefficient Pump Control by Throttling

Throttling is effective in reducing flow from pumps, but is not an efficient method because of the energy wasted across the throttle, although it is widely used as a flow setting or controlling technique. Ideally pumps should be operated within a range of flows centred around peak efficiency flow if problems are to be avoided and high efficiency achieved. Therefore the range over which throttling should be employed, if at all, is limited.

As a consequence of over-design, most of the steel industry pumps examined have been found to be operating at less than the peak efficiency flow, i.e. throttled to some degree. They cannot, therefore, achieve their maximum efficiency and although they are using less power than they would at full flow, energy is being wasted in all these systems.

Throttling is usually applied by using a valve on the outlet of a pump to vary the flow. The effects of this can be illustrated using pump characteristics, as in Fig 4.

Assume that a pump and its system are well matched such that the normal system resistance line crosses the pump head/flow curve at a point, A, corresponding with peak efficiency flow, Q_A. By partially closing the throttling valve the flow is reduced to Q_B as the system resistance increases according to a new line which crosses the head/flow curve at B.

Under these circumstances the pressure head generated at the pump outlet has risen from H_A to H_B, although the useful head has fallen from H_A to H_C. Therefore the difference between these two values is equivalent to the head loss across the throttling valve, i.e. the wasted energy.

The efficiency has also fallen, i.e. less of the energy being absorbed by the pump is being converted to pressure and flow.

The power required by the pump has fallen by a small amount, but not by as much as might be expected. This is because even at zero flow, the pump will absorb some power (very roughly around half of the power absorbed at peak efficiency).

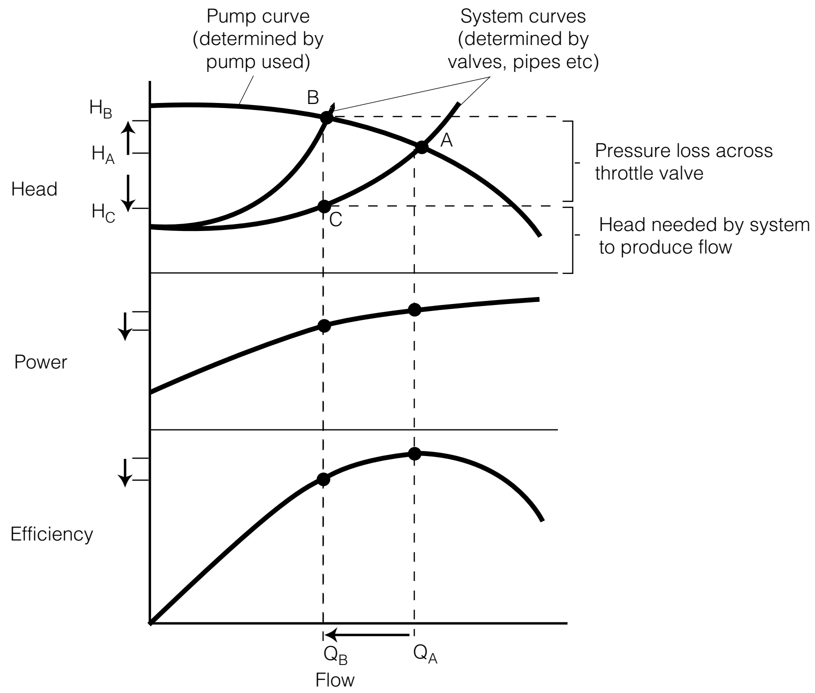

Fig 4 Illustration of the effect of throttling a pump

4.8 Less Efficient Impellers

For each pump there is a range of *impeller* sizes which can be fitted, each size producing different pump performance. Often pump characteristics are displayed as in Fig 5 to demonstrate this.

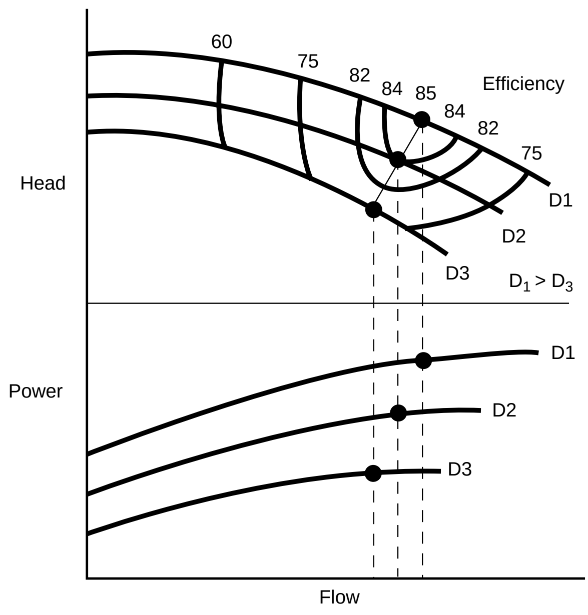

Fig 5 Pump characteristics showing various impeller diameters

The characteristics usually show maximum and minimum permissible diameters, plus one mid-range. Note that the maximum efficiency value can only be achieved with the largest impeller size. The peak efficiency value falls off as the size decreases. However, the peak efficiency flow also decreases. System designers make use of this fact by opting to use pumps which can achieve the desired duty with less than the maximum impeller size. This allows them to fit a

larger impeller at some later date should the water requirements increase. Unfortunately, this can lead to a larger pump than necessary being fitted, and can also cause a marginal loss of efficiency.

The important points to note here are that:

- a pump fitted with a reduced size impeller will be less efficient than a smaller pump fitted with a full sized impeller when matched to the same duty;

- although smaller impellers are less efficient they also develop less head and flow whilst using less power.

4.9 Oversized Pump Motors

When selecting a motor to match a pump it is common to choose one which is sufficient to meet the power requirement at the right-hand end of the pump characteristic, i.e. to cater for ‘end of curve run-out’. It is unlikely that this will fall right on the mark for a particular size, therefore the next size up will be chosen. In an oversized pump which is throttled to run at less than optimum flow, this could mean that the motor is only lightly loaded. In such a case, although extreme, the motor efficiency could be a few per cent less than at full load.

4.10 Misuse of Parallel-pumps

For many reasons, such as reduction of current required or security of supply, pumps are often used in banks of three or more. In a bank of three it is usual to find two running and one on standby.

Contrary to commonly held beliefs, the flow does not double on addition of a second pump. In fact each successive pump adds a smaller amount to the total head and flow (although the total flow is split equally between the pumps).

Pumps operating as a pair in parallel should be matched with the system such that each of them operates close to its peak efficiency flow, as in the example below. Under such conditions it is inadvisable to switch off one of the pumps.

Another factor is that worn pumps cost more to run to achieve the same flow. When a pump wears it tends to shift its performance and generally tends to generate less flow and head whilst operating less efficiently (therefore requiring more power).

Poorly designed pipework adjacent to pumps can lead to turbulence at the pipe inlet and outlet which can produce vibration and possibly mechanical damage, for instance where adjoining pipework turns through bends of 90° of fairly tight radius close to the pump.

We can examine the characteristics of two pump operation by two examples.

In the first example illustrated in Fig 6 the system resistance is ideal for one pump operation and would produce a flow of Q_1. By adding in the second pump the total flow moves to Q_2, corresponding with point A where the system resistance line crosses the two pump curve. Each individual pump delivers half this flow and operates at point B, using a smaller amount of power (though twice that power is used in total) and operating at a lower efficiency. The net difference is a small gain in head and flow for a significant increase in power.

Pumps operating as a pair in parallel should be matched with the system such that each of them operates close to its peak efficiency flow.

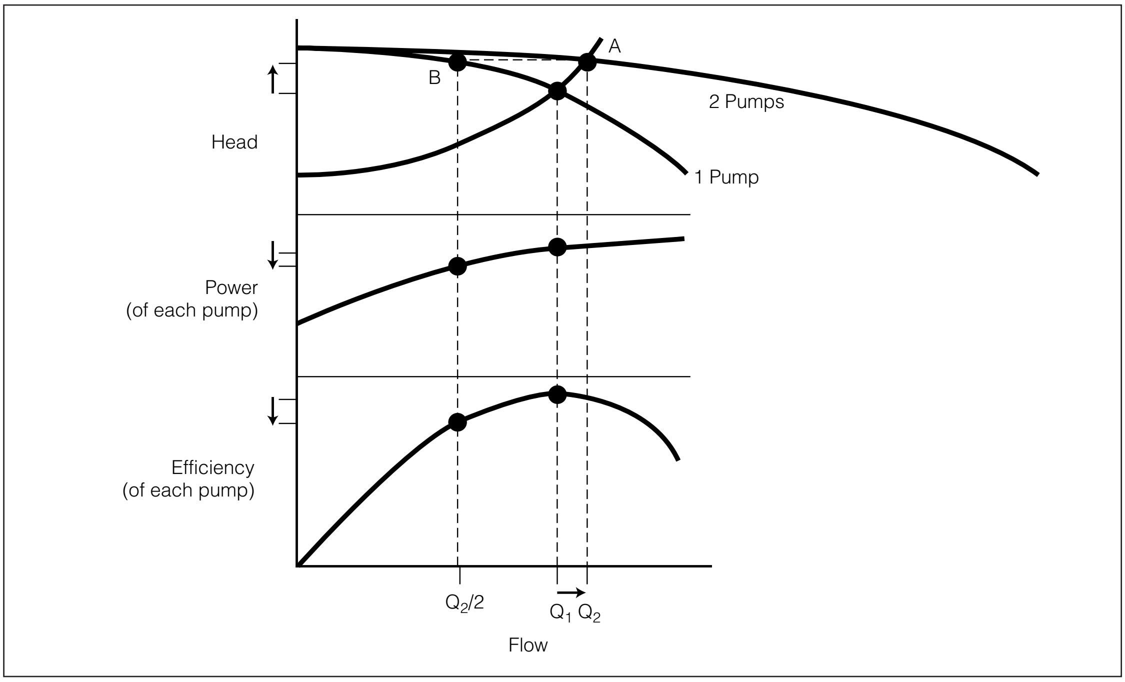

Fig 6 Parallel-pump operation - designed for a single pump

The second example illustrated in Fig 7 shows ideal system resistance for two pump operation.

Under these conditions it is inadvisable to switch off one of the pumps. If this were done, the remaining pump would assume operation at point C towards the end of its curve, where lack of *net positive suction head* ($NPSH_A$) and motor power limitations might cause problems. $NPSH_A$ is defined and explained in Fig 32, Section A2.3.

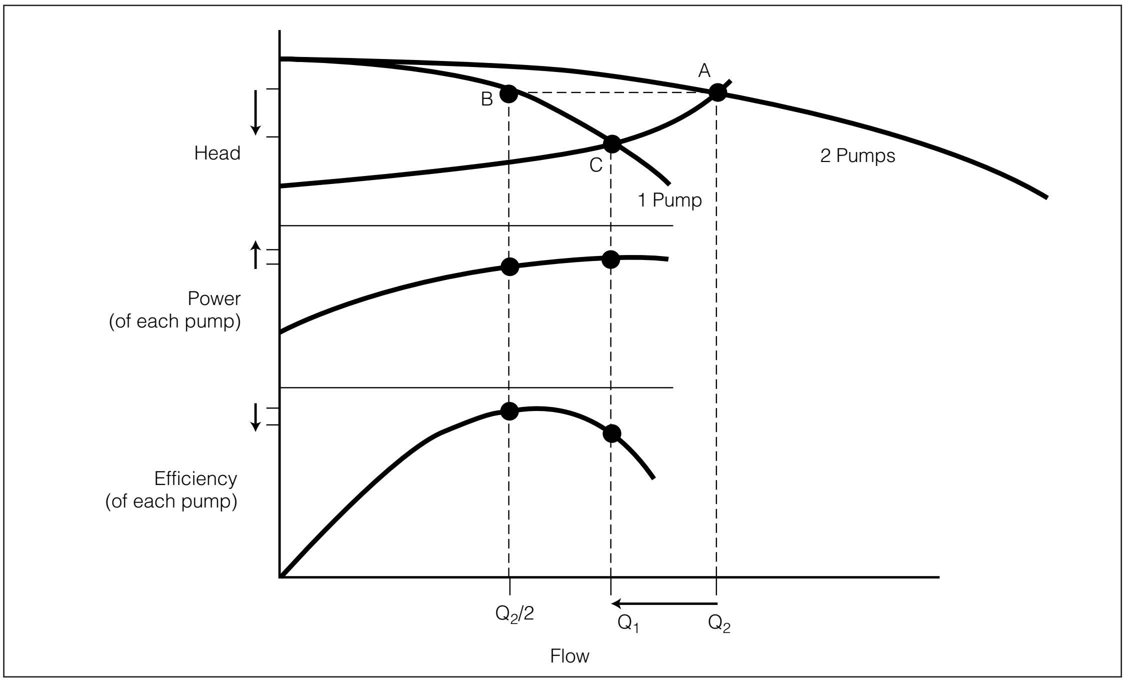

Fig 7 Parallel-pump operation - designed for two pumps

Occasionally, pumps are used in banks of more than three, although it is rare to find more than six in parallel. This arrangement is sometimes used to give a degree of flexibility to the quantity of water pumped. However, the benefits are not always as expected.

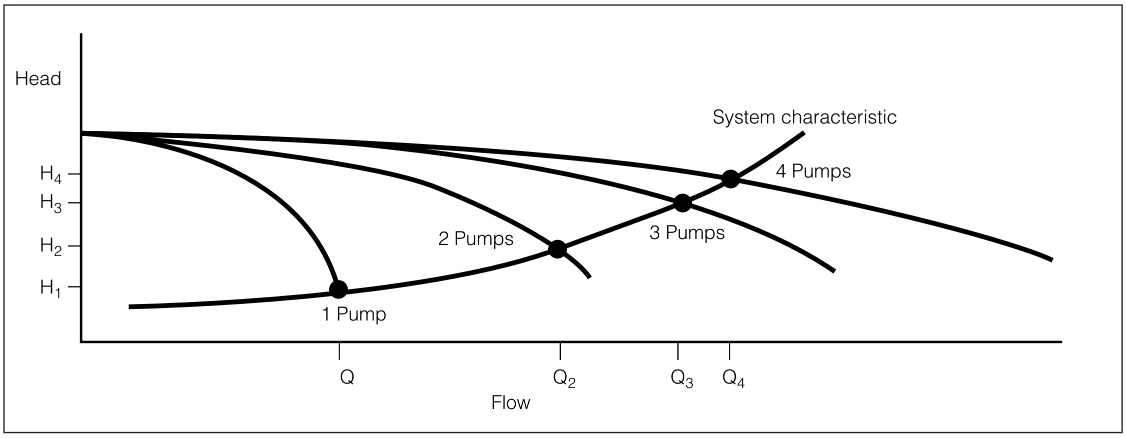

Fig 8 Multiple pumps in parallel

Fig 8 illustrates how each successive pump adds a smaller amount to the total head and flow (although the total flow is split equally between the pumps). Therefore, when operators decide to ‘add another pump’ to ensure they have enough water available, they could be achieving very little, whilst generating additional costs. Changes in system resistance would be required to maximise the benefits of varying the number of parallel-pumps in use.

4.11 Pump Wear

The main cause of pump wear is poor water quality. High concentrations of particulates (especially if abrasive such as mill scale) and low pH values are common problems which cause wear through erosion and corrosion. They are normally partially controlled by filtration and water treatment, although some degree of wear on steel industry pumps is inevitable. *Cavitation* damage can also cause wear and thus impair pump performance.

Typical wear problems are; internal leakage between high pressure and low pressure sides of a pump through *neck ring* seals, impeller wear, and casing wear.

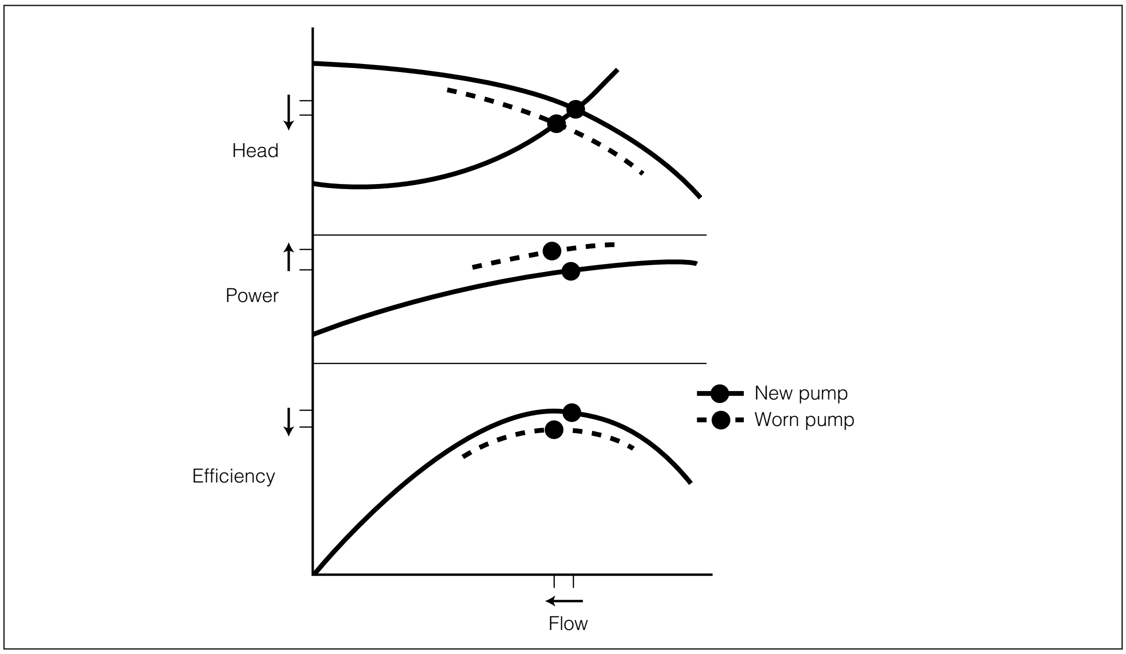

Fig 9 Effect of wear on pump characteristics

When a pump wears it tends to shift its performance characteristics as shown in Fig 9. Generally (although not necessarily) a worn pump tends to generate less flow and head whilst operating less efficiently (therefore requiring more power), i.e. worn pumps cost more to run to achieve the same flow.

Data collected from many pump tests have been averaged to produce the trend for pump wear shown in Fig 10.

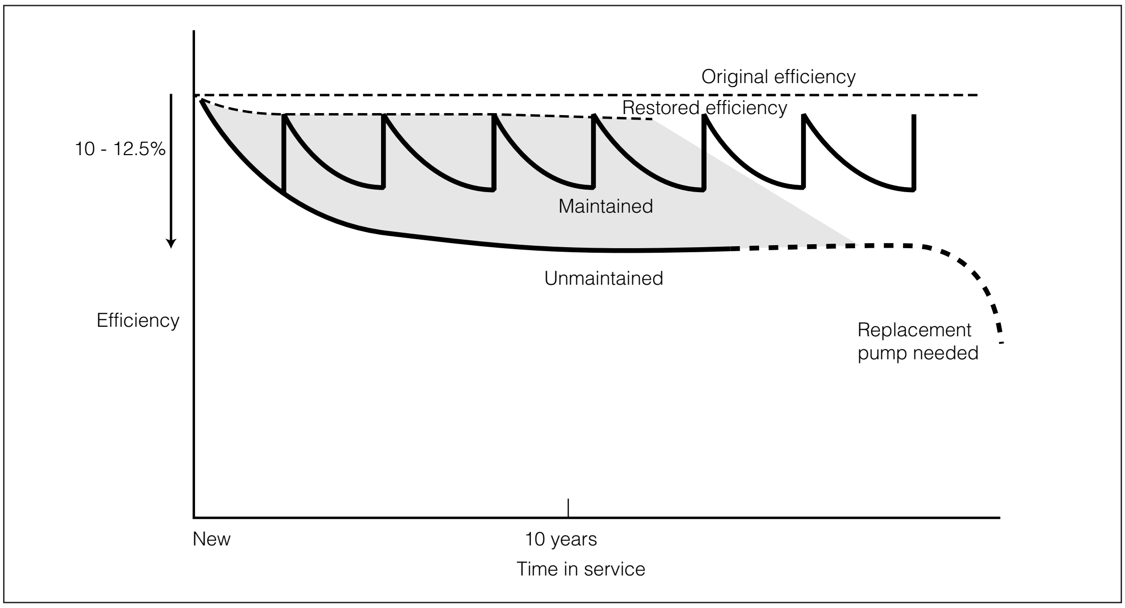

Fig 10 Average wear trends for maintained and unmaintained pumps

This trend suggests the following:

- much of the wear occurs in the first few years until clearances become of similar size to the abrading particulates;
- after about 10 years the wear tends to level out;
- the overall drop in efficiency for an unmaintained pump could be around 10 - 12.5%;
- an unmaintained pump could reach catastrophic failure after around 20 years service.

By periodically maintaining the pump, by refurbishing/replacing the neck ring and impeller, efficiency can be returned to a level close to that when new. The maximum loss of efficiency is attributable to pump casing wear. It is important to note that the data are an average for many pumps and that poorly maintained pumps can fail catastrophically in a very short time.

4.12 Pump Inlet Restrictions

To help prevent solid matter from being drawn into pumps they are usually fitted with some form of inlet filter, e.g. a wire mesh basket. Unless these filters are kept clear and unblocked they can cause low pressure at pump inlets, i.e. lack of $NPSH_A$. In some cases this leads to a loss of pumping efficiency, but in extreme cases cavitation occurs within the pumps causing physical damage. Partially blocked inlet filters are the most common problem encountered in steel industry pumping systems, and this is probably a result of lack of maintenance.

4.13 Poorly Designed Pipework Adjacent to Pumps

Traditionally, pumps were fitted with flared pipe sections on their inlet and outlet. At the inlet side this accelerates water towards the pump and helps keep pipework resistance down, i.e. $NPSH_A$ up. At the pump outlet, correct water velocities require greater diameter pipework than the pump outlet flange size. In both cases a flared section of gradient around 1:20 should be used. In some newer installations flares have not been fitted, or where they have been used they have a steep gradient or are stepped. Worse still, the adjoining pipework often turns one or more 90° bends of fairly tight radius close to the pump. Such practices can lead to increased turbulence at the pump inlet and outlet, producing vibration and possibly mechanical damage.

4.14 Jammed Non-Return Valves

Most banks of parallel-pumps are fitted with non-return valves as shown in Fig 11. Ideally, the valves should create very little pressure drop when fully open on running pumps, and form a good seal when pumps are not running. Poorly maintained valves can stick partially open, or partially closed. When not fully open the extra system resistance created forms an effective throttle on running pumps. If not fully closed on standby pumps, the valves can pass water (which should have been delivered to the process) through the pumps, causing them to rotate in the reverse direction. In both cases, pumping efficiency is impaired and a reduced flow is produced.

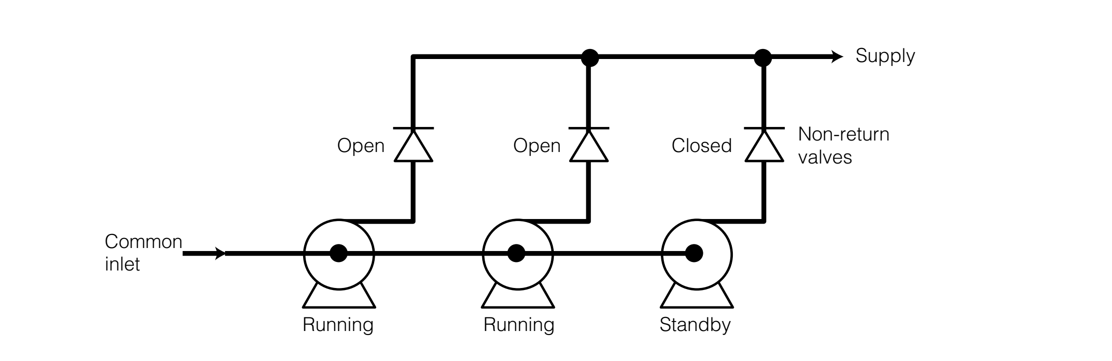

Fig 11 Schematic of a three-pump bank with non-return valves

4.15 Inappropriate Water Velocities

Designers of pipework systems should aim for water velocities of around 2 m/s by selecting appropriate pipework diameters. Lower velocities can lead to silt collection and eventually rotting pipework. Higher velocities lead to increased system resistance, which requires increased pumping power. They can also increase abrasive wear on pipework and valves, especially if the water contains particulates such as mill scale.

4.16 Inadequate Metering, Monitoring and Control

Metering equipment on steel industry pumping systems is often inadequate, unless the water supply is vital, e.g. on continuous casting systems where meters are used largely to generate low flow alarm signals. If no alarms are generated then it is considered that the water supply is satisfactory. However, the pumps may be operating inefficiently at high costs. Basic metering that should be present on all pumps are ammeters and inlet pressure gauges. Other metering equipment could include flow meters, but these tend to be fitted only to the vital supplies. In some cases the results from water system metering are logged but this tends to be purely for reference in case of incident or failure. Rarely are such figures used to identify the potential for pumping system changes or for monitoring energy use. Sensible, cost effective pumping and regular analysis of results can provide useful information to improve operating costs. Further details on this subject are available in Good Practice Guide (GPG) 91 *Monitoring and Targeting in Large Manufacturing Companies.*

As there is a general lack of metering equipment, water systems are largely unmonitored, making problems difficult to detect. The quantities of water pumped and the energy consumed are often unknown. This makes control of pumps and systems relatively crude, relying mainly on manual intervention rather than automatic adjustment. Some basic automatic systems may be in place, e.g. level control on scale-pits where the number of pumps in operation is dictated by water level.

Flow control valves are employed in some systems where a variable quantity of water is to be delivered, e.g. on cold mill roll coolant supplies. These devices are effective in controlling flow but in doing so create other changes. They create some pressure drop in order to function

correctly, but at the same time excessive upstream pressures are commonly found and so add to the wasted pumping energy.

Modern technology, such as variable speed drive pumping, is making some impact on steel industry pumping costs, although the uptake is quite slow. Further details on this subject are available in GPG 14 *Retrofitting AC Variable Speed Drives.*

4.17 Inadequate Documentation

With so many steel industry pumping systems of considerable age it is not surprising that documentation on systems and components is often poor. Many pumps do not have original characteristics, although design duty details are usually held on record. Since the original installation, there may have been many modifications to systems and water requirements, which may not have been well documented. Without such details it is difficult to ascertain pump capabilities, true system requirements and the scope for savings. There is also no basis for comparison of subsequent monitoring.

4.18 Summary

The main problems can be summarised as follows:

- pumps can operate inefficiently through over-design, wear and the extensive use of throttling as a static control technique;

- lack of maintenance on pumps and systems can exacerbate problems;

- pumped quantities can be excessive through over-design and safety margins or through arbitrary judgement of cooling needs;

- water can be pumped unnecessarily to inactive plant items;

- systems are often set to accommodate maximum water demands but cannot cope efficiently with demand changes;

- diversion and recirculation are employed as crude control techniques, but these save little or no energy;

- new technology which helps match pumping with water requirements is becoming more common, but is being introduced slowly and with caution;

- operators may be unaware of wasted energy and high pumping costs, through the lack of metering equipment and monitoring;

- without system documentation some operators may be unaware of their system details and true water requirements.

All of these factors contribute to the high pumping costs within the steel industry. Some can be remedied with little or no capital outlay. Others require investment but can produce savings which give very attractive short payback periods followed by continued savings.

5. COST SAVING OPPORTUNITIES

Having examined typical steel industry pumps and pumping systems, and identified the many problem areas, possible solutions must be considered. These solutions can be grouped under the following headings:

- maintaining;
- modifying;
- monitoring.

5.1 Maintaining

In order to restore a worn pump to an efficiency close to its original value, it must be at least partially refurbished. This might include replacing the rotating element (the impeller plus its neck rings), the bearings and the seals. This is a comparatively simple operation on a split-casing pump, but it may cost several thousand pounds as the rotating element is its most costly component. Also, the casing will not be restored to the original internal dimensions, therefore some efficiency loss (compared with original characteristics) will remain.

The benefits of refurbishment have to be judged on individual merit, but as with all savings options involving pump performance improvement, it should be borne in mind that running costs predominate in the lifetime cost breakdown and that small increases in pump efficiency can produce worthwhile savings. Note that a worn pump produces less flow, and if this is proved adequate, on completing refurbishment the pump flow should be set to the lower value in order to obtain the maximum savings benefit, as illustrated in Fig 12.

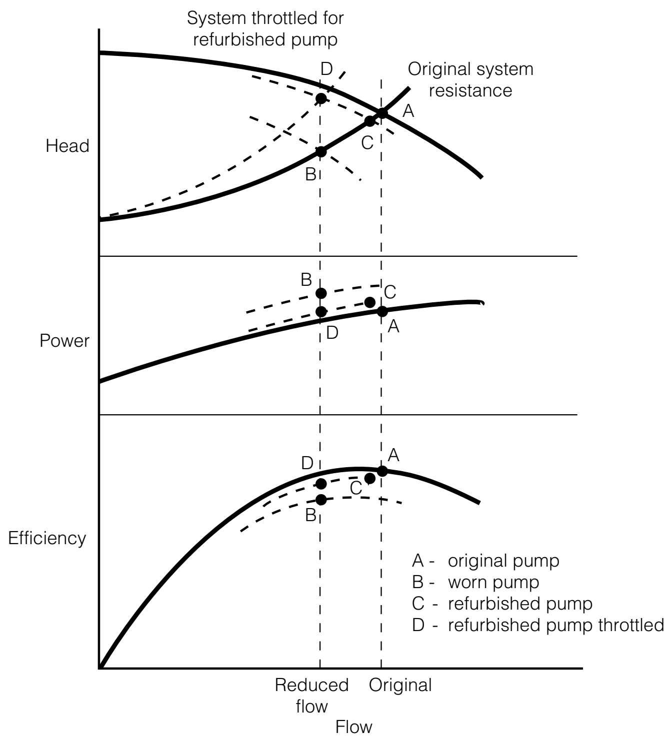

Fig 12 Effect of refurbishment on pump characteristics

Other opportunities for maintenance actions to contribute towards savings include:

- routine cleaning of pump inlet filters;
- routine checking of non-return valves;
- curing leaks.

5.2 Modifying Equipment

5.2.1 *Internal Coatings*

A range of materials referred to as *coatings* have been developed for applying to the internal components of pumps to modify the surface properties of the host material.

Corrosion/Erosion Resistant Coatings

These coatings can be applied where conditions are severe because of a need to pump corrosive liquids or liquids containing abrasive particles. The coatings help prevent exposed surfaces from being worn away, and maintain component dimensions and clearances. Efficient operation is therefore sustained and the need for pump maintenance is reduced. Such coatings need to be applied to all of a pump's internally exposed surfaces, including the impeller.

Low Friction Efficiency Enhancement Coatings

Low friction coatings tend to be less robust than corrosion/erosion resistant coatings but do afford good corrosion resistance where applied. However, their main purpose is to provide an extremely smooth surface (compared with the host material) and create less friction with the high velocity water inside the pump. In this way the pump can produce elevated pressure and flow for a similar (or reduced) power input. A coated pump therefore, can, be more efficient.

New pumps can be coated on purchase and expected to give a higher efficiency than an uncoated pump by around 2 or 3%. Worn pumps can be coated (with appropriate preparation) and will exhibit an efficiency improvement, although results are less predictable.

Low friction coating materials are normally either glass-flake based or polymer based. The latter can be applied very thinly so that the hydraulic dimensions within the pump are barely changed. However, glass-flake based coatings are considered to have improved adhesion to the host metal, but can be 1.5 to 2 mm thick. When using a thick coating on a new pump, efficiency improvement tends to be confined to flows lower than the design flow, and the peak efficiency flow can be reduced, as illustrated in Fig 13.

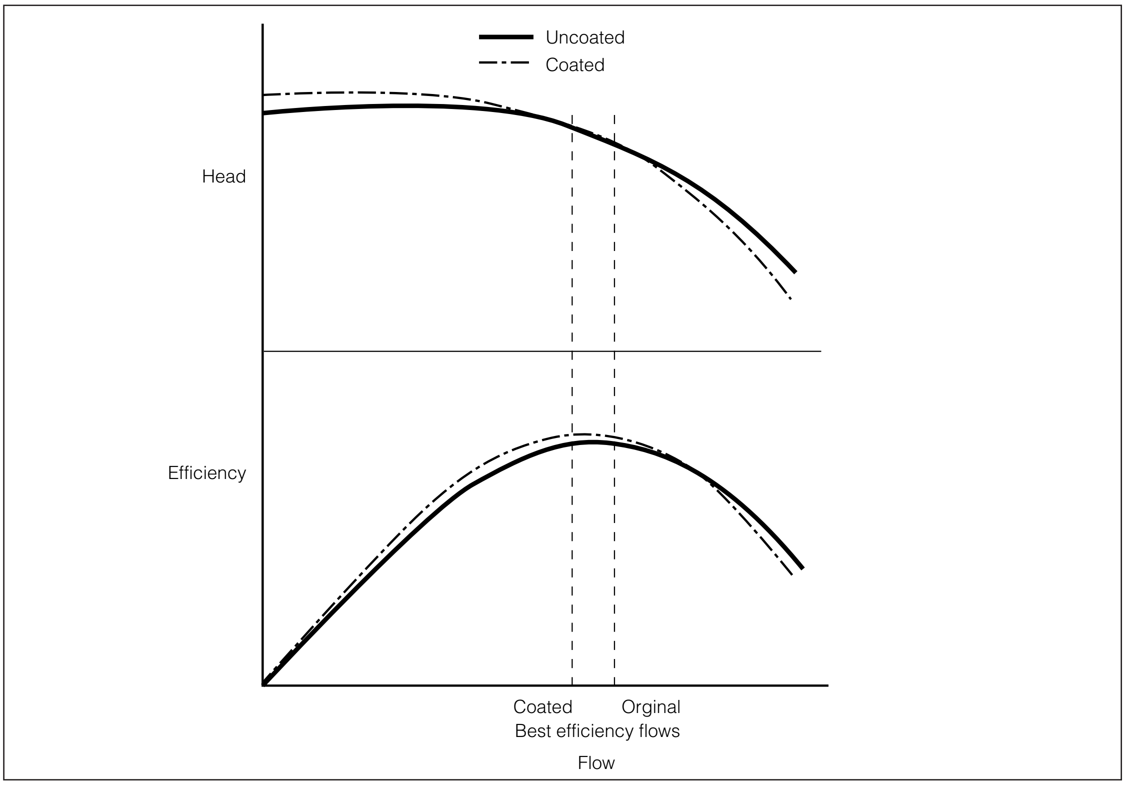

Fig 13 Potential effect of coatings on new pump characteristics

However, most pumps are over-designed and tend to operate to the left of their peak efficiency flow, thus as the flow is reduced by the coating, an efficiency improvement can be expected. On worn pumps, although wear will be localised rather than uniform, the thicker coating might be more beneficial in restoring internal dimensions around the wear areas. Worn pumps would usually be coated at the same time as being refurbished and, unlike normal refurbishment work, efficiency could be restored to the original value, or above.

Preparation for coating includes sandblasting and chemical testing to ensure that the host metal surface to be coated is sound and salt free. A multi-layer coating application follows. The whole process is usually conducted by specialists, although some coatings can be applied on site under supervision.

With efficiency enhancement coatings it is usual to coat only the casing and the outer faces of the impeller to reduce the main frictional losses, i.e. casing surface finish loss and disc friction loss.

In summary, the benefits of efficiency enhancement coating are:

- an improvement in pump efficiency which can lead to reduced running costs;
- some extra corrosion resistance on the parts coated;
- prolonged high efficiency performance compared with an uncoated pump.

Pump internal coatings are currently being studied by 'The Pump Centre' (part of AEA Technology) in a project aimed at providing a better understanding of how they can benefit pump users.

5.2.2 *Changing Impeller Sizes*

As has been mentioned earlier in this Guide, the type of pumps in common use within the steel industry can be fitted with a range of impeller sizes. Maximum efficiency is available only with

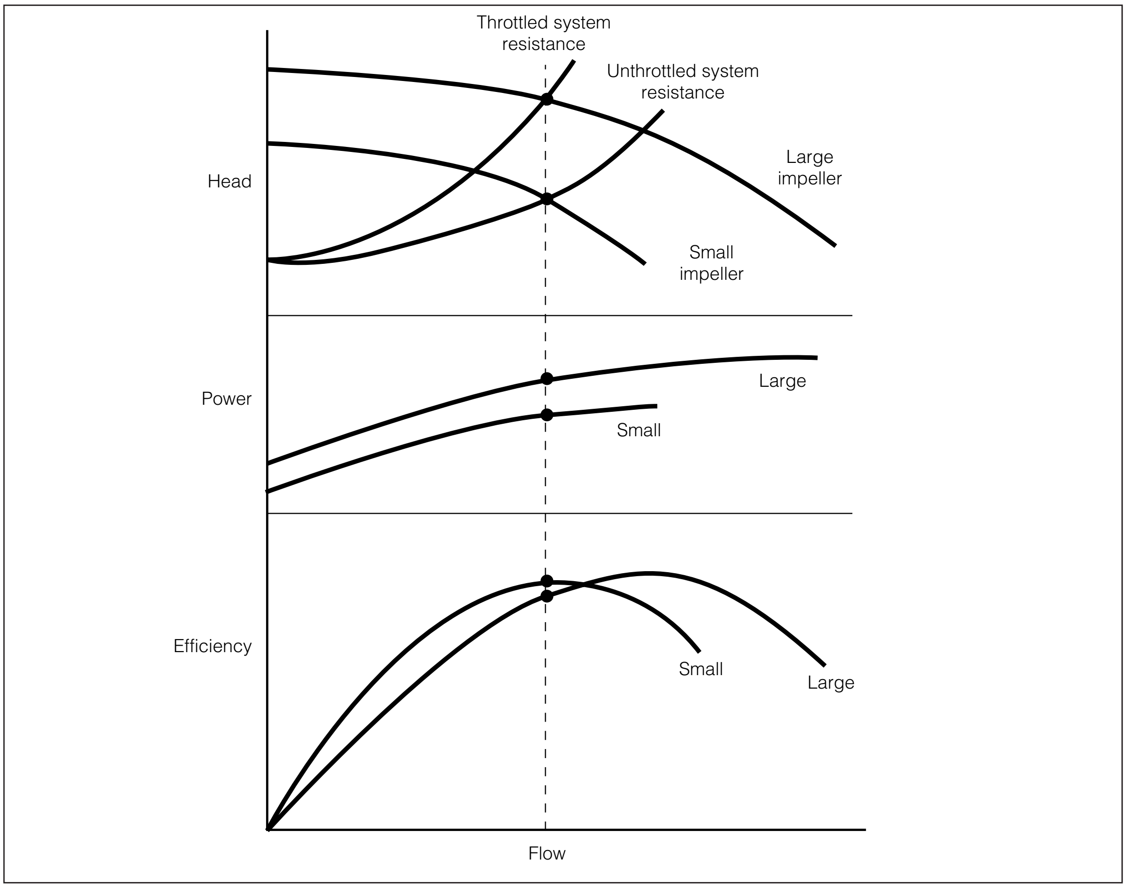

Fig 14 Effect of reducing impeller diameter on pump characteristics

the largest size impeller, as illustrated in Fig 14.

The range of acceptable sizes is often shown on manufacturer's characteristics for a particular pump, otherwise the generic curves for the pump type showing the impeller size range should be available from the manufacturers.

In some circumstances the range of impeller sizes can be used to save pumping energy. For example, if a pump is always throttled to some degree and not operating at peak efficiency then it may be possible to use a smaller impeller to generate a similar flow at a lower head (whilst opening the throttling valve) and thereby demand less power. This method of matching pump performance with water requirements would be an expensive option if it entailed purchasing a new rotating element. However, the existing oversized impeller can be removed from the pump and trimmed in a lathe to reduce its diameter and achieve the desired results. Obviously this is a one-way procedure which should not be undertaken without guidance from pump experts. Nevertheless, it is a valuable technique which is commonly applied in order to change pump operating performance and save pump energy.

5.2.3 *Using Smaller Pumps*

This can be an economic option if:

- pumps are too large for their maximum duty;
- pumps are less than around 80% efficient at their maximum duty;
- energy use is high, i.e. where large pumps are running for long hours.

For example, if a pump has to be throttled to produce the required maximum flow it may be possible to employ a smaller pump which is designed to deliver this flow more efficiently, as illustrated in Fig 15.

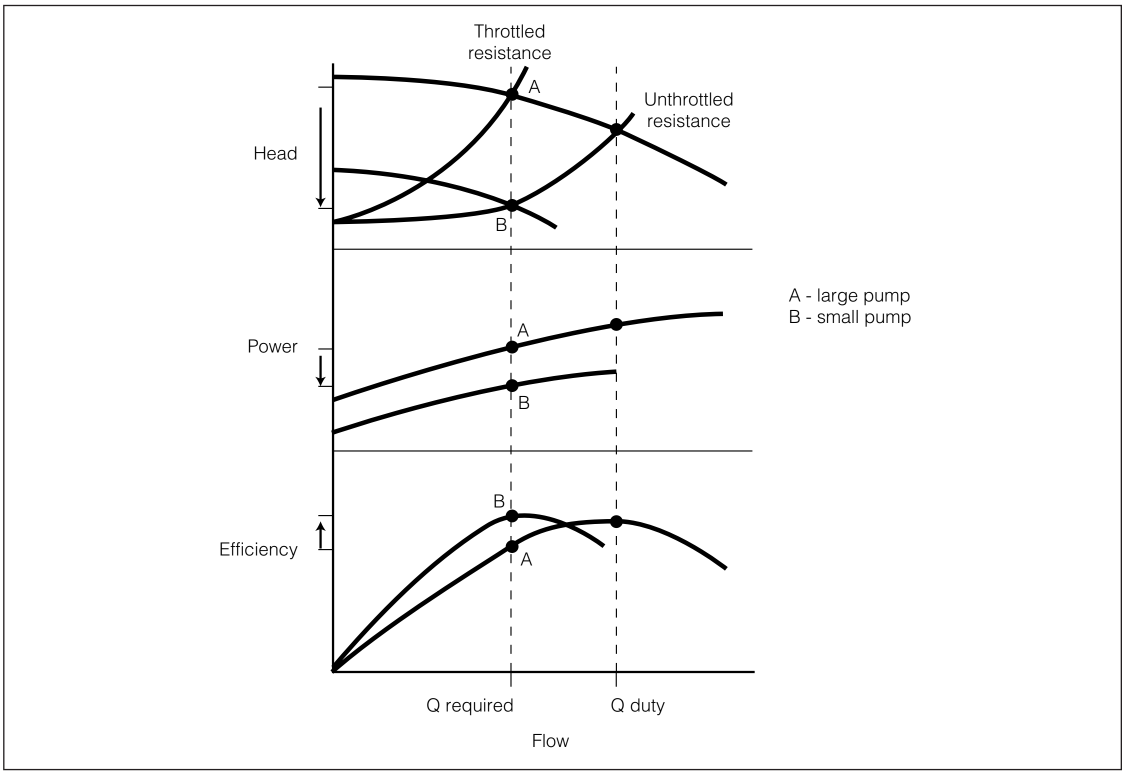

Fig 15 Effect of using a smaller pump

5.2.4 *Energy Efficient Motors*

In recent years a new design of motor has been developed which consumes less electricity than comparable standard motors for any given load. This is achieved by employing more copper and iron in their construction to reduce the motor losses. Typical motor efficiencies for a range of motor sizes are shown in Fig 16.

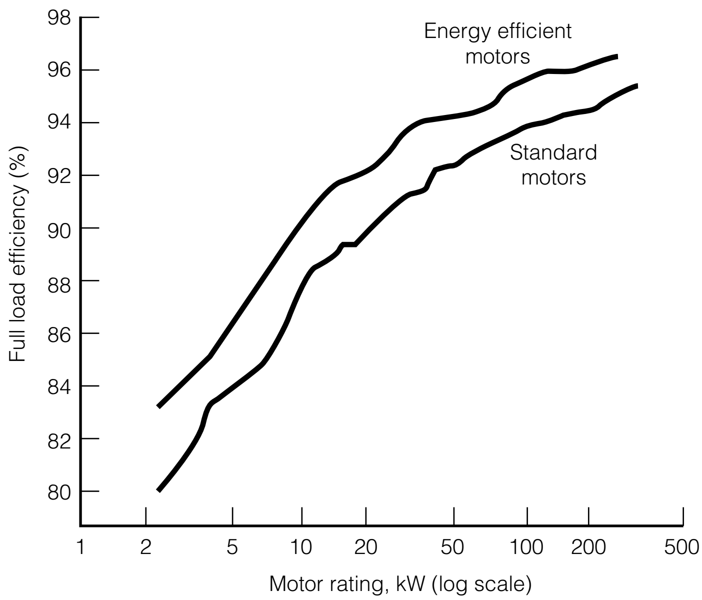

Fig 16 Efficiency comparison of 'Energy Efficient' and standard motors

Energy efficient motors can achieve efficiencies about 2% higher than normal motors but are more expensive to buy. This premium may be quickly repaid when it is considered that a motor operating continuously can consume its capital cost in electricity within one month.

It has already been said that, through over-design, pumps are often too large for their required duty. The same can apply to their motors too, and this can mean that motors are operating at well under full load. Energy efficient motors maintain their efficiency margin at low loads and continue to give energy savings benefits.

Energy efficient motors have a tendency to be slightly longer than the equivalent normal motor but provided this can be accommodated they can easily be retrofitted to existing pumps. Further details on this subject are available in GPG 2 *Guidance Notes for Reducing Energy Consumption of Electric Motors and Drives* and in Future Practice R&D Profile 50 *Higher Efficiency Induction Motors.*

5.3 Modifying Operation

5.3.1 *On/Off Control*

If periods can be identified when water is not required then it may be possible to switch off pumps until the water is needed. This can be done manually, but simple control measures may be appropriate, e.g. level switches, temperature switches, timers, etc.

Frequent re-starts are inadvisable because they generate shock loads and high motor currents which produce heating effects. Although a typical limit is six starts an hour for the type of motors driving steel industry pumps this is not advisable as a regular practice. The use of on/off control might be limited, therefore, to lengthy stoppages (where predictable), downshifts and weekends.

5.3.2 *Soft-starting*

A soft-starter is an electronic unit which fits between a motor and its electricity supply. It provides smooth, gentle motor acceleration which prevents shock loading and reduces the heating effect on the motor. Therefore an increased re-start frequency is tolerable, allowing pump users to take advantage of the many instances of short duration when water is not required, e.g. during production stoppages and delays, or when tanks are full/empty. Further details on this subject are available in GPG 2 *Guidance Notes for Reducing Energy Consumption of Electric Motors and Drives*, and New Practice Final Profile 79 *Variable Speed Drives on a Steel Mill's Water Pumping System.*

5.3.3 *Variable Speed Pumping*

The pump characteristics discussed so far have been those resulting from fixed speed operation. However, by reducing the motor speed, and hence pump speed, it can be seen that a family of characteristics can be generated throughout the speed range as shown in Fig 17.

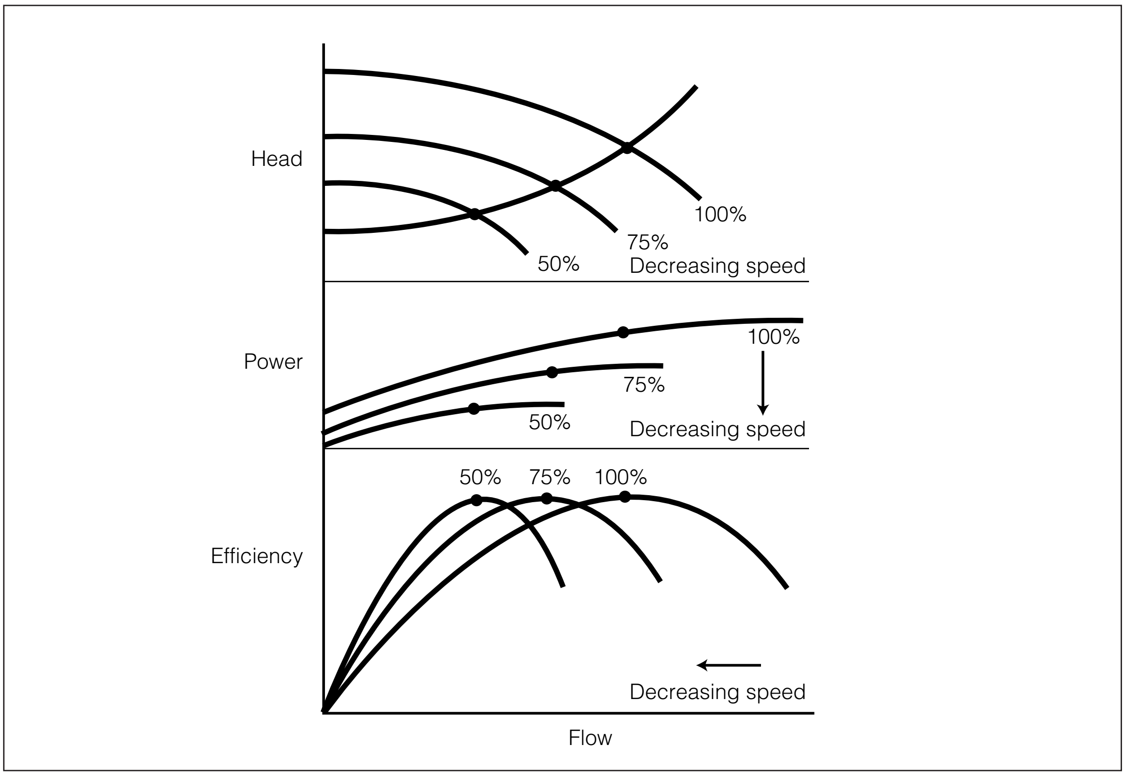

Fig 17 Effect of speed reduction on pump characteristics

Further details on this subject are available in GPG 2 *Guidance Notes for Reducing Energy Consumption of Electric Motors and Drives.*

Represented another way, as in Fig 18, it can be seen that the efficiency remains high at flows between 60% and 100% of the design flow. At lower flows the efficiency falls off rapidly, although this varies with pump size and is less severe with larger pumps.

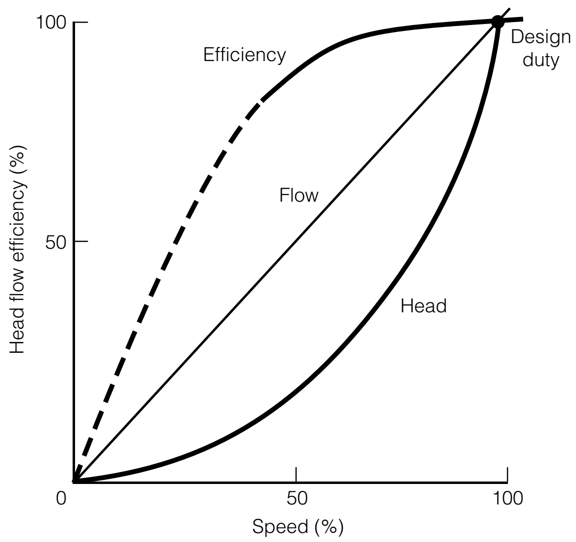

Fig 18 Variation of head, flow and efficiency with pumping speed[1]

The variation of pump performance with speed is usually described by the Affinity Laws, which state that:

Flow	α	Speed
Head	α	Speed^2
Power absorbed	α	Speed^3

So, at 50% speed a pump generates 25% head and absorbs only 12.5% power. In a system where there is no *static head* component these relationships can be used directly to estimate the savings potential of reduced speed operation. However, as most real systems have some static head component the relationships must be modified to account for this. In the example illustrated in Fig 19, at 40% speed, 40% flow would be produced through the system with no static head, whereas no flow would be produced through the system with static head.

To help pump users assess the savings potential of variable speed pumping there are software programs freely available for use on PC compatible computers, e.g. from ETSU. These programs require a minimum of input data and will select default information if users are unsure of the correct input.

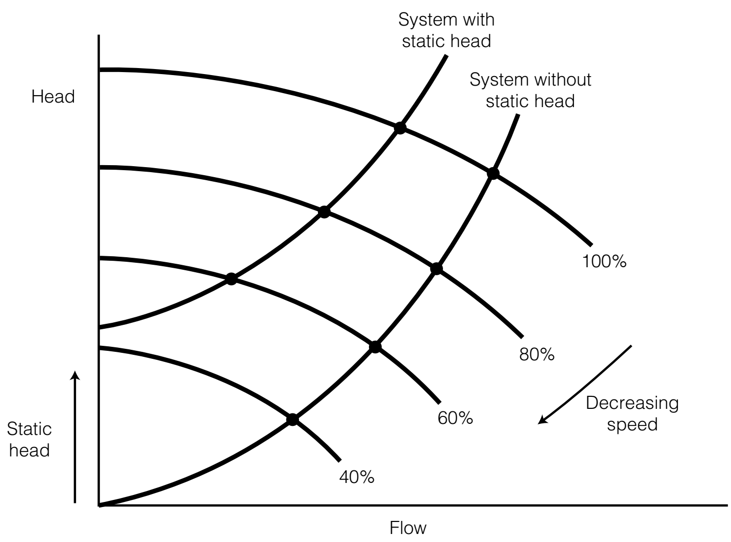

Fig 19 Effect of static head on reduced speed pumping

[1] Note that Fig 18 is only correct when the system head is entirely frictional, i.e. there is no static head component.

The main benefits of pump speed control are:

- to facilitate matching pumping with flow requirements;
- to permit a tight control over pumped flows;
- to eliminate energy wasted by throttling the pumps;
- the inclusion of soft-starting.

The *variable speed* drive itself is somewhat similar to the soft-starter in that it is usually a box (but larger in this case) which fits between a pump motor and its electrical supply. The most common type of variable speed drive employed on pumping systems is the pulse width modulated (PWM) *inverter*, although there are other types. The PWM inverter is very efficient and adds little further electrical losses to a pumping system. Unless the pumps are being driven at full speed constantly (in which case an inverter is unnecessary) then the potential savings can far outweigh any drive inefficiencies.

The control of a variable speed drive can be manual, but is usually automated, based on feedback signals from the system generated by measurement or control devices such as flowmeters, level indicators and pressure transducers. Some degree of interfacing could be necessary, especially for non-standard signals.

In multiple pump arrays it is normal for all pumps to run at the same speed so that their characteristics remain matched. This can be achieved by equipping each pump motor with a separate inverter then using a common control signal. It is possible to mix variable-speed pumps with full-speed pumps, although the range of speed reduction available to the controlled pumps can be limited (depending on the system resistance).

The cost of variable speed drives is high, but falling as the technology expands. Furthermore, the cost savings benefits can often produce short payback periods.

Applications for variable speed pumping should satisfy both of the following conditions to produce the most attractive savings:

- the water demand is variable and less than 100% for long periods, allowing prolonged operation at reduced speeds;
- system resistance is mainly frictional, allowing operation at the lowest speeds (see Fig 19).

Note that if pumps always operate at less than 100% flow then they are too large. Selecting smaller pumps might be a more suitable alternative than a variable speed drive, especially if demand variations are small.

5.4 Monitoring

5.4.1 *Pump Efficiency Testing*

Traditionally it has been difficult to measure pump efficiency under installed conditions. Obtaining the required measurements when faced with on-site difficulties and constraints largely precluded efficiency assessment once pumps had been installed. The development of a practical thermodynamic technique has solved many of these problems allowing a direct calculation of efficiency in real time, solely from measurements of temperature and pressure increases across the pump. This has been made possible by the development of sophisticated temperature probes capable of measuring only a few millidegrees. With simple temporary on-site installation of temperature and pressure probes at the inlet and outlet of a pump, the energy losses during pumping (i.e. the energy which is not converted to water flow and pressure) can be measured, and hence the efficiency of the pump calculated. In association, a measurement

of the power input to the pump allows the flow rate to be calculated. The results can then be compared directly with manufacturer's characteristics for that pump to gain an indication of its true hydraulic condition. This not only shows whether the pump performance has deteriorated through wear, but shows whether or not the pump is operating in the region of peak efficiency. Furthermore, the inlet pressure measurement can detect possible NPSH problems which might cause cavitation, e.g. low inlet pressure due to partially blocked inlet filters. All individual pumps in a bank can be compared under similar conditions to identify the most economical combinations of pumps.

The equipment for conducting such tests was first packaged into a convenient form by Advanced Energy Monitoring Systems Ltd and was referred to as a *Yatesmeter*. Others are now available. Such a device provides a convenient means of obtaining valuable information about pumps and their operation as part of a system. Routine testing on most pumps can help to identify savings possibilities in terms of equipment maintenance, water control, operating hours, etc.

On vital pumping systems with large pumps, a permanent efficiency monitor installation might be appropriate to ensure that operation at peak efficiency is maintained.

5.4.2 *Pump Monitoring*

It would be beneficial to pump operators if all pumps were equipped with inlet and outlet pressure gauges and their motors fitted with ammeters. Inlet pressures can be monitored to ensure that inlet filters are not allowed to block and restrict the $NPSH_A$. Outlet pressure can provide some indication of how well a pump performs compared with its original characteristics (although the head/flow characteristic is usually quite flat making precise comparisons difficult). Ammeters can help in estimating pump running costs, although this requires an estimate of the motor power factor. For better comparisons with characteristics and estimates of running costs, flowmeters and kWh meters would be more useful, but these are unlikely to be fitted except to large, vital pumps. By keeping regular records of readings from pressure gauges and ammeters, however, it should be possible to identify any changes in operation which could be indicative of problems or excessive energy use, e.g. increased power use or decreased pump pressure. Further details on this subject are available in GPG 91 *Monitoring and Targeting in Large Manufacturing Companies.*

A more sophisticated monitoring method would be to employ a fixed efficiency monitor for continuous assessment of pump performance. This is an expensive option and could only be justified for pumps which are continuous high energy users and which must be kept in optimum condition. However, once tappings have been fitted to the pump inlet and outlet, spot checks using portable efficiency monitoring equipment can be conducted quickly and easily. These should aid problem diagnosis as well as providing information which could help improve pump or pumping system efficiency.

5.4.3 *System Monitoring*

A small number of steel industry sites have invested in sophisticated computer based monitoring which can also provide some degree of control. The systems comprise remote out-stations where a range of monitoring signals, such as pressures, flows, currents, levels, etc. are read. In turn, several out-stations communicate with a base-station capable of producing graphic displays of system data and report printouts. The base-station can also generate alarm signals for any of the measured parameters, and in some instances can be used to control plant items, e.g. switch pumps on or off. The benefits of such monitoring are that a whole water system can be observed and its operation compared with plant activity enabling opportunities to match pumping with requirements to be identified, as can excess pumping, unnecessary pump operation and leaks. This kind of monitoring demands that pump and system documentation must be complete and up to date. Further details on this subject are available in GPG 31 *Computer Aided M&T for Industry.*

6. CASE HISTORIES

Some steel industry pump users have recognised the large energy saving possibilities on their water systems and even though capital expenditure has been required, in some cases payback periods have been favourable. The following examples each used a different technique to achieve savings.

6.1 Minimising Recirculation in a Works Water Supply System

A steelworks main water supply was fed from a high-level tank which was topped up continuously by a large supply pump drawing from a low-level freshwater tank, as shown in Fig 20. The works water consumption was around 1.5 million gallons/day, although this varied somewhat with production activities. A Yatesmeter test on the supply pump revealed that it was pumping close to 3 million gallons/day. The excess water from the high-level tank simply overflowed back to the low-level tank, i.e. up to half of the water being pumped was merely being recirculated.

As a solution the high-level tank was fitted with level controls to switch off the pump when the tank is full, and switch it on again before the tank empties. In this way the overflow should never occur and up to half of the pumping costs are being saved.

Initial pumping costs	£20,000/year
Estimated savings	£7 - 10,000/year (35 - 50%)
Estimated outlay	around £1,000
Estimated simple payback	<6 weeks

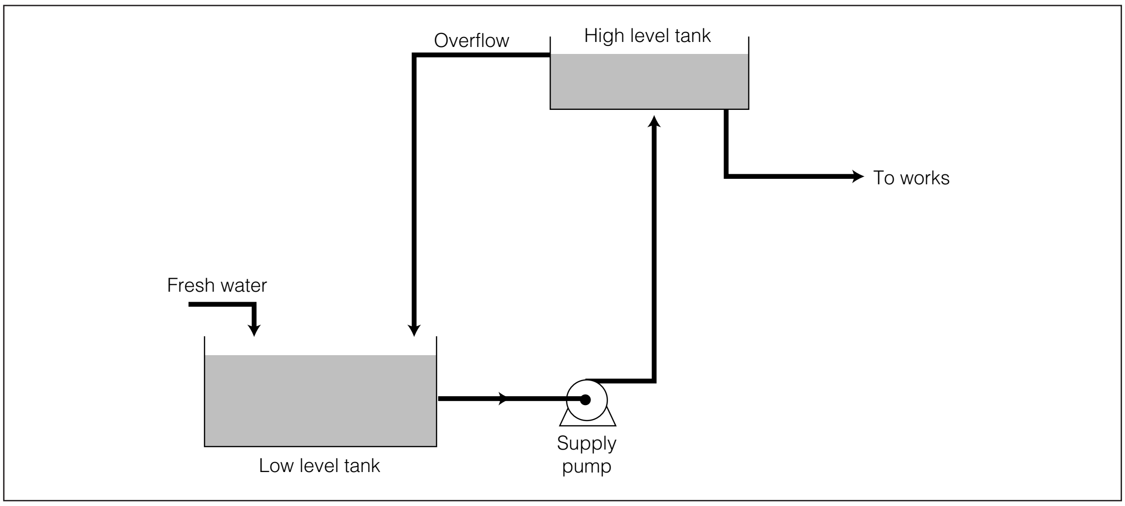

Fig 20 Schematic of works water supply pumping system

6.2 Dispensing With the Fourth Parallel-pump for Reheat Furnace Cooling

A bank of five parallel-pumps rated at 50 kW each was available to provide cooling water to various components of a small reheating furnace. For some time it was considered that three pumps would provide adequate cooling, but more recently it had become standard procedure to use four pumps (though there had been no equipment or operational changes). From Yatesmeter pump efficiency tests it was found that the head and flow produced by each pump was close to the original performance curve, but through wear the efficiencies were around 10% lower than expected and consequently power consumption was higher at around 54 kW per pump. The annual running cost for four pumps was estimated to be £52,000/year.

By estimating a system resistance curve and superimposing this on a set of combined head/flow curves for four pumps as in Fig 21, it could be shown that the addition of the fourth pump did not add greatly to the total pumped capacity.

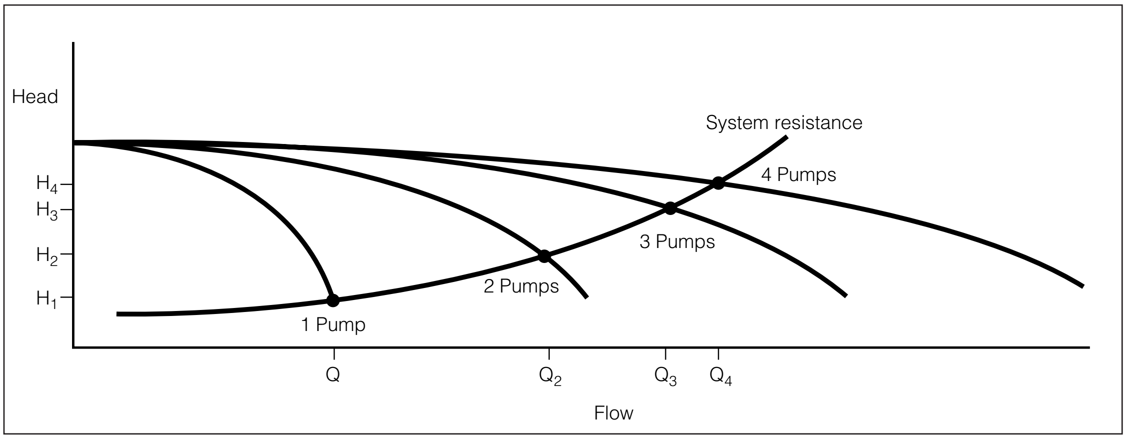

Fig 21 Combined characteristics of four furnace cooling pumps operating in parallel

Potential savings for different options are indicated below:

Option 1: Revert to Three Pump Operation
Using the estimated curves it was deduced that operating with just three pumps would provide around 91% of the four pump flow whilst saving some 41 kW (19% of the original power requirement). At this steelworks the saving was worth £10,000/year. Three pump operation had been adequate in the past and the works personnel agreed that they could implement it again whilst considering other savings options. The modification of operating practice was very simple, immediate and involved zero cost.

Option 2: As Option 1, but using Refurbished Pumps
The depressed pump efficiencies that were measured indicated that the pumps were in need of remedial maintenance. Refurbishment would have allowed them to operate more efficiently with a reduced power requirement. Although it was not expected that the efficiencies could be restored to that of new pumps, it was estimated that adopting a three pump operation with refurbished pumps would have increased savings to around 60 kW, worth £14,500/year. Note that in judging the relative merit of a case such as this it is only the extra savings (£4,500/year) which should be weighed against the extra costs (for the refurbishment of three pumps).

Option 3: As Option 1, but using Three New Pumps
As an alternative to refurbishing old pumps, new pumps of the same type could have been purchased (whilst retaining the existing motors). This would have maximised the available efficiency and further reduced power requirements. It was estimated that by adopting a three pump operation with new pumps the savings could be increased to around 70 kW (33%), worth £17,000/year. The cost of three new pumps was in the region of £10,000. Therefore the payback based on the extra savings (over and above those from Option 1) would have been 1.5 years.

6.3 Operating With One Less Blast Furnace Gas Washer Pump

A bank of four parallel-pumps was available to provide water for washing and cooling blast furnace off-gas. One pump was almost large enough to deliver sufficient water, but not quite. Therefore, it was expected that two pumps would be used. However, if one of these two pumps were to fail, the other would assume a duty, not only beyond its efficiency peak, but also beyond the maximum power rating of its motor. Therefore it would trip-out and leave no water supply. As this water system is critical to blast furnace operation complete failure could not be tolerated. Therefore three pump operation was accepted as the norm. Total power absorbed was 634 kW which costs around £170,000/year.

The solution adopted here was to trim the impellers of the three pumps by a small amount such that in an emergency situation any one of them could run alone without tripping its motor, then to use only two pumps for normal operation rather than three. The third pump became the standby.

The impellers were trimmed at the machine shop of the host steelworks and other routine maintenance was conducted on the pumps at the same time. The total cost involved for three pumps was less than £10,000. The savings from this scheme were estimated at £44,000/year (26%) to produce a simple payback of around three months.

6.4 Eliminating Continuous High Volume Pumping to a Plate Mill Laminar Cooler

This particular project is a New Practice Case Study 79 in the range of Energy Efficiency Best Practice programme publications. Four parallel-pumps were available to supply water to a laminar cooler at a plate mill. The cooler reduces the temperature of hot rolled plate to within a target temperature band as the plate passes through it. A series of headers with many siphon nozzles (or upward sprays from below) direct water onto the steel. Different types and thicknesses of steel require different amounts of cooling and this is adjusted manually by an operator who sets the header array in use. Three or four pumps (depending on operator preference) were in continuous use so that energy use and pumping costs were not related to production, but were fairly constant. A simple schematic of the arrangement is shown in Fig 22. The pumping costs for this system were £86,000/year.

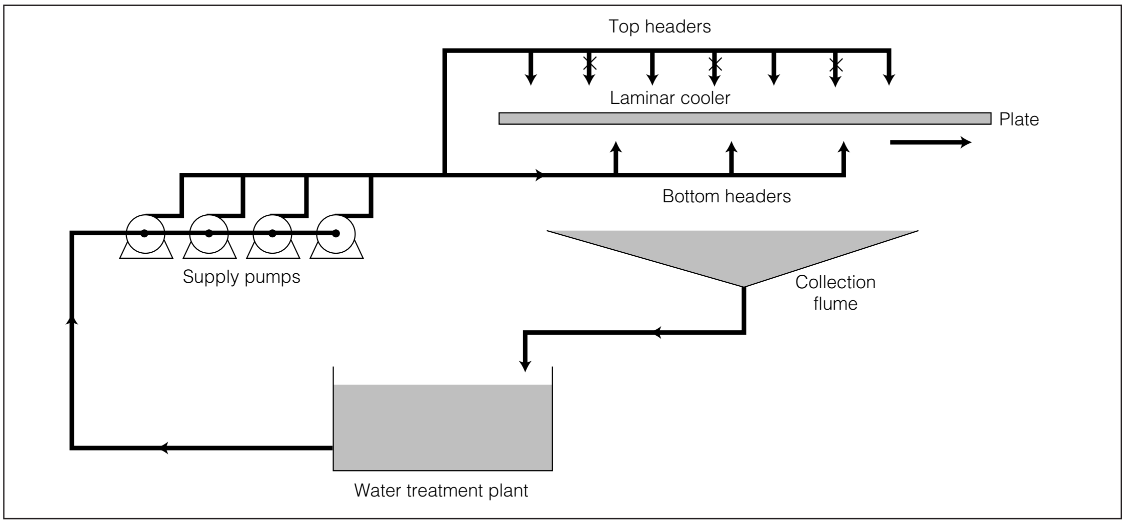

Fig 22 Schematic of plate mill laminar cooler system

The system was wasteful of energy for a number of reasons:

- water to unselected headers was diverted straight to flume;
- three of the top headers were never used, yet their water was also diverted straight to flume;
- water was still pumped throughout any delays or stoppages, or lengthy gaps between plates;
- the pumps were tested each weekend, then left running until the start of rolling, wasting around 16 hours of pumping every week.

The works decided to fit variable speed drives to all four of the pumps and to introduce its operation in two phases.

Phase 1: On/Off Control

The variable speed drives provided a soft-starting facility and it was only this feature that was used for pump control in Phase 1. Existing hot metal detectors before and after the cooler were used to provide control signals indicating hot plate approaching and leaving the cooler. In

response, the pumps were run (at full speed) only when plate needed cooling, thereby dispensing with pump operation through non-production periods and weekends.

The energy use began to show a better correlation with production as displayed in Fig 23 and at the average production rate the savings would have been equivalent to 42%, worth £36,000/year.

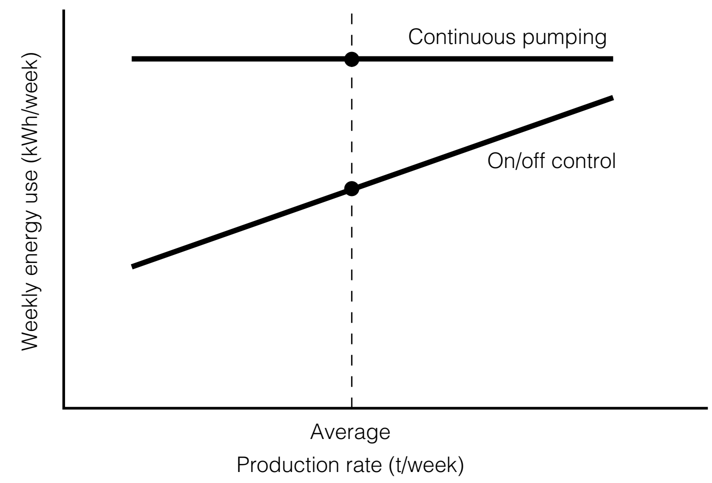

Fig 23 Illustration of energy savings from on/off control

Phase 2: On/Off Control Enhanced by Variable Speed Pumping
Once Phase 1 operation had been fully implemented the system was developed to the next phase where the existing on/off control was enhanced by using variable speed pumping to match cooling requirements. The divert routes from all headers (including those never used) were capped off to eliminate unnecessary recirculation. A simple algorithm was developed to select one, two or three pumps to match approximately the pumping with water demand (header array in use). The water flow was then finely adjusted by using a pressure feedback signal from the main supply manifold to control the common speed of those pumps. In this way, whatever the header selection in use, the pumping system was matched to it in terms of number of pumps in operation and their speed. At this stage the energy use and savings increased to 76% as illustrated in Fig 24, and are worth £65,000/year.

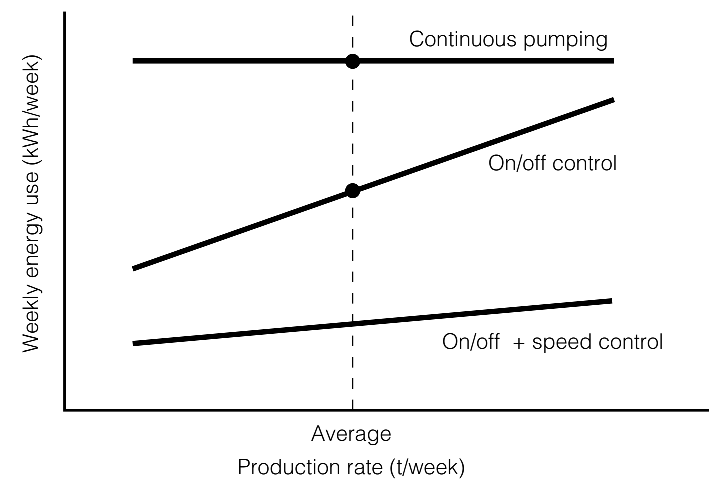

Fig 24 Illustration of energy savings from on/off plus variable speed control

The works had a high capital outlay for this project although this was largely because of the unsuitability of their existing equipment and its operating voltages. The simple payback period for them was 3.25 years, but could be expected to be significantly shorter for similar projects at other sites.

6.5 Matching the Variable Demand of a Mill Roll-cooling System

A large rolling mill uses two supply pumps to provide cooling water to all of its mill stands for roll-cooling. Used water drains through flumes into scale-pits for return to a water treatment plant and cooling tower in an open recirculation system. A schematic of the system is shown in Fig 25.

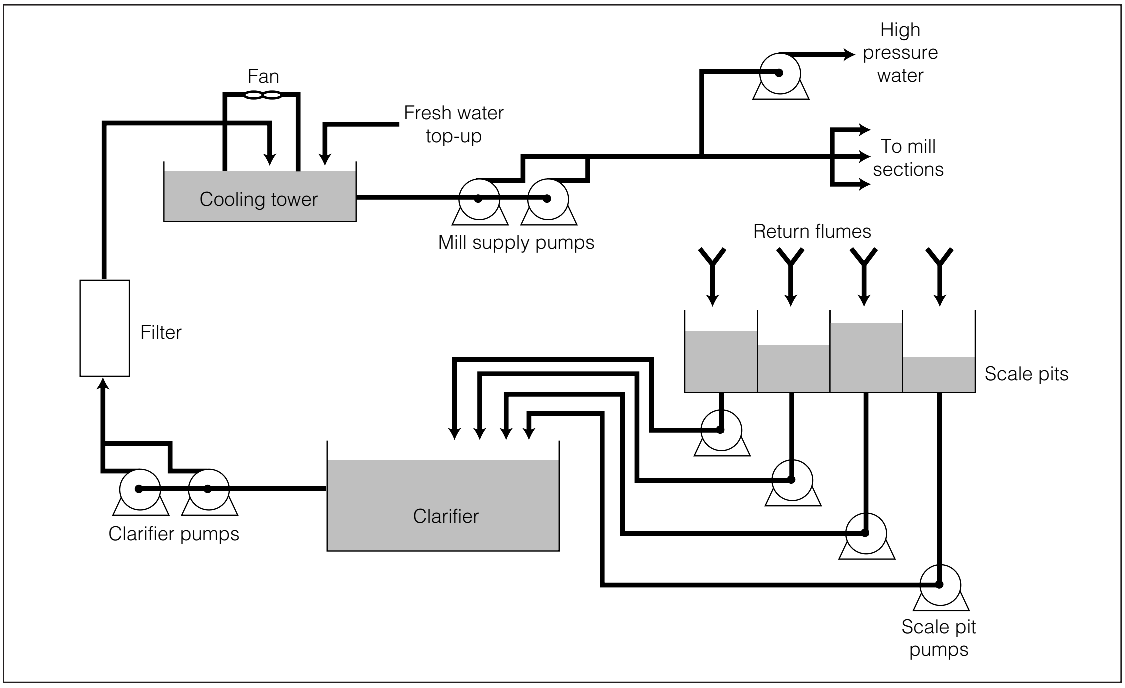

Fig 25 Schematic of rolling mill roll-cooling system

Water demand is variable because of production stoppages and delays, and because finishing sections of the mill are not always in use. The largest change in demand is caused by intermittent use of high pressure water for scarfing purposes and this is fed from the mill cooling system via a booster pump.

Originally, two mill supply pumps were used at all times, although their capacity was greater than the water demand, even when scarfing. Between scarfing operations just one pump would have been sufficient.

In order to save energy at the supply pumps, one has been fitted with variable speed drive so that its speed can be controlled from the water pressure in the main supply manifold. The second pump was fitted with a soft-starting facility so that if the first pump cannot achieve sufficient pressure, even at full speed, the second pump is introduced. With this type of pump control the plant operators were able to reduce the control pressure gradually whilst checking that adequate cooling was provided. In addition, they eliminated by-pass routes from unused mill sections. Now, one pump running at less than full speed is adequate for all operations except scarfing. During scarfing the second pump joins the first and both operate at full speed.

The benefits of supply pump control are passed on to the other pumps in the recirculating system, as they also handle less water. Prior to this project the supply pumps used £104,000/year of electricity but the total for all the pumps in the system was £218,000/year. By employing the scheme outlined, the plant is saving £90,000/year (41%) and their simple payback period was less than six months.

6.6 Increasing the Efficiency of Pumping for Continuous Caster Mould Cooling

A bank of three pumps was available to provide mould cooling water for a continuous slab caster. One pump was almost large enough to provide sufficient water, but not quite. Therefore two pumps were used, each absorbing 208 kW of power. Yatesmeter tests revealed that these pumps could only achieve efficiencies of at best 73% and as they ran against a throttle they were achieving efficiencies of only 66%. Annual running costs were £114,000/year.

In this case it was decided that an economical solution would be to purchase new equipment more suited to the water requirements. It was found that a single pump of the correct size could supply the desired amount of water to the caster whilst operating at an efficiency of 85%. It would absorb only 165 kW, representing a power saving of 60% worth £68,000/year. Furthermore, because the new pump was more efficient and could deliver more water with a lower power demand, the existing motor could be retained. The capital outlay for two pumps (one running and one standby) would have been around £12,000, although substantial pipework changes to accommodate them in the tightly packed pump house elevated costs. Nevertheless, a simple payback of only a few months was expected.

Before the project was progressed an uprating of the caster was announced and this increased the water demand. At this stage it was discovered that the upstream pressure on the flow control valves (which control the flow to each mould face) was higher than necessary. In fact, a 2 bar reduction in pressure could be tolerated. This relaxed the pumping requirement again so that a single pump (albeit larger than originally planned) would suffice. The savings from this scheme have been estimated at £57,000/year (48%) and a simple payback of well under one year is thought possible.

7. ACTION PLAN

Further details on the following are available in GPG 91 *Monitoring and Targeting in Large Manufacturing Companies.*

7.1 Existing Water Systems

7.1.1 *Costs*

- Find out the costs of water, treatment, sewerage, electricity and estimate the cost of running all of the pumps on a system.
- Use the costs to justify retrofitting of energy savings features.
- Use monitoring and targeting (M&T) techniques, if appropriate, for increasing awareness and controlling costs.

7.1.2 *Water Use*

- Find out where all the water is being used. Are all of the uses effective, or are some wasteful and even unnecessary?
- Identify the true maximum water requirements.
- Identify the variations in this requirement.
- Develop routine checks and information logging to gauge system water use and pump energy use trends.
- Find and eliminate water leaks.

7.1.3 *Systems*

- Minimise any diversion and recirculation from unused items of plant.
- Minimise pumping during process interruptions.
- Consider alternatives to throttling for flow control.
- Minimise other energy uses (e.g. from cooling tower fans) where possible.
- Check if pressure upstream of flow controlling devices could be reduced.
- Fit control equipment to aid efficient system operation, e.g. level controls, thermostats, timer switches etc.
- Avoid static control of recirculating systems to achieve a fixed water balance. Aim for dynamic control which can quickly respond to changes in process activity.
- Ensure system documentation is complete and current.

7.1.4 *Pumps and Motors*

- Ensure that pump inlet pressures are adequate and that inlet filters are clear.
- Attend to any *cavitating* pumps immediately.
- Repair badly leaking seals.

- In parallel-pumping sets check if all running pumps are needed.
- If pump performance is in any doubt, seek an efficiency test.
- If pumps are due for overhaul consider the benefits of applying an efficiency enhancement coating, or of purchasing new pumps.
- If pumps never reach their design duty, then they are too large. Fit smaller impellers or fit smaller pumps.
- If water requirements are intermittent then on/off control might be suitable. Check with motor manufacturers whether soft-starting is required.
- If water requirements show large variations then variable speed pumping might be attractive. Consult motor manufacturers about the suitability of retrofitting VSD's.
- Consider the control implications for the rest of a recirculating system if the supply pump operation is to be varied.
- If motors are due for replacement would smaller units of a lower power rating be appropriate (to save capital cost and possibly improve motor efficiency)?
- Consider the benefits of using energy efficient motors when replacing motors.

7.1.5 *Metering and Monitoring*

- Ensure metering equipment is functioning correctly.
- Fit appropriate metering devices where they are absent.
- Develop data collection routines to assess pump and system operation and trends.
- Consider the benefits of fitting an electronic monitoring system.
- Use M&T techniques where appropriate to identify and help maintain efficient operation.

Further details on this subject are available in GPG 91 *Monitoring and Targeting in Large Manufacturing Companies.*

7.1.6 *Maintenance*

- Use information from monitoring to identify problems and schedule maintenance.
- Take the opportunity to fit metering equipment when pipework is modified or replaced.
- Ensure pump inlet filters are kept clear.
- Maintain pumps to ensure efficient operation. Keep records of all pump maintenance.

7.1.7 *Training*

- Ensure pump and system operators have at least some basic knowledge of pumping principles.
- Ensure that data on energy use and savings achieved is freely available to operating staff and can be understood by them.

7.1.8 *Energy Savings Schemes*

- From available data develop ideas for energy savings schemes.
- Estimate savings potential, costs and payback potential.
- Seek support and funding.
- Publicise successful schemes.
- Replicate successful schemes.

7.2 New Water System Designs

7.2.1 *Costs*

- Budget for energy savings features which will help save running costs.
- Find out the water costs and disposal costs - could these be minimised (e.g. by using lower grade water)?
- Find out the water treatment costs.
- Find out the electricity costs.
- Estimate the running costs and overall costs - use these to justify fitting energy savings features.
- Consider the least expensive energy savings features first (but initial expense must be balanced against cost savings benefits).

7.2.2 *Water Use*

- Are there possibilities for using lower grade water?
- Could discarded water from another process be used for this one? Could water discarded from this process be used elsewhere?
- Check on specified water requirements to limit over-design and safety margins.
- Minimise extra water uses, such as scale flushing.

7.2.3 *Systems*

- Use a recirculating design, but minimise unnecessary recirculation.
- Minimise static head requirements.
- Design pipework for optimum water velocities (2 m/s).
- Minimise unnecessary system pressure drops, especially on descaling systems.
- Minimise overpressure upstream of flow control devices.
- Avoid unnecessary system throttling.
- Avoid throttling as a means of flow control.

- Avoid sharp bends in system pipework, especially close to pumps.
- Use inlet and outlet flares.
- Ensure the provision of adequate $NPSH_A$.
- Aim to control supply pump operation to match process demands.
- For open-circuit systems use dynamic control so that return pumps can respond to changes in supply pump operation.
- For closed-circuit systems, design energy saving features into the secondary circuit, e.g. thermostatic control of secondary pumps and cooling tower fans.
- Minimise additional energy use, e.g. cooling tower fan operation.
- Design water delivery nozzle arrays and stand-off distances for minimum water use and pressure requirements, especially on descaling systems.

7.2.4 *Pumps and Motors*

Further details on this subject are available in GPG 2 *Guidance Notes for Reducing Energy Consumption of Electric Motors and Drives* and in GPG 14 *Retrofitting AC Variable Speed Drives.*

- Select pump sizes which match water requirements efficiently.
- Select pump sizes which use the largest (or close to largest) impeller size.
- Select pump sizes to match immediate water requirements rather than long term future requirements.
- Select efficient pumps.
- Consider the benefits of internal coatings, especially efficiency enhancement (low friction) coatings.
- Obtain manufacturer's pump tests for each large pump rather than generic characteristics.
- Consider how variations or interruptions in water requirements can be most efficiently dealt with.
- If pumps are to operate in parallel then use as few as possible (within electrical constraints).
- Aim to operate pumps at, or close to, their design flow.
- Select motor sizes to correspond with pump design flow. Cater for 'end of curve' operation only if this is likely to occur.
- Consider the benefits of using energy efficient motors.
- Consider how pumps can be controlled to match water requirements efficiently.
- If on/off control is an attractive option check with motor manufacturers whether soft-starting is necessary.

7.2.5 *Metering and Monitoring*

- Ensure pumps and systems are equipped with adequate metering, e.g. ammeters, inlet and outlet pressure gauges.

- Fit kWh meters to large pump motors.

- Ensure critical pumping systems are equipped with reliable flowmeters.

- Make provisions for pump efficiency testing, i.e. fit pressure tappings at either side of pumps (according to recommendations from testing organisations).

- Consider installing a fixed efficiency monitor on critical pumps.

- Consider electronic monitoring on large systems where water costs and running costs are high.

- Make all pump and system details, together with water use specifications, available to pump and system operators.

- On commissioning, develop efficient water use and operating practices. Use these as ‘fingerprints’ or ‘benchmarks’ for continued efficient operation.

7.2.6 *Maintenance*

- Make provisions for quick and simple maintenance on all parts of the system, especially on pumps and their inlet filters.

- On commissioning, identify maintenance requirements and develop maintenance routines.

7.2.7 *Training*

- Ensure operators have an adequate knowledge of their system and its efficient operation.

Further details on this subject are available in GPG 85 *Energy Management Training.*

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9. GLOSSARY

Cavitation	The formation and collapse of vapour bubbles, usually in an impeller entrance section, caused by insufficient inlet pressure. Thus in regions of high velocity the vapour pressure of the liquid is greater than the absolute pressure.
Centrifugal pumps	An impeller rotating at high speed within a stationary casing. The action of the impeller throws the liquid within the impeller towards the outside of the casing to generate pressure.
Coatings	Materials applied to the inner surfaces of a pump (those in contact with the pumped liquid) to form either a low friction surface to reduce pump losses, or a protective layer to reduce erosion/corrosion.
Efficiency	The efficiency (of a pump) with which the shaft power applied (not the power to the motor) is converted to head and flow. Motor efficiency is the electrical equivalent of this parameter for the motor.
Flooded suction	The pressure at the pump inlet caused by the height of water above it. It is one of the factors which can contribute towards the $NPSH_A$. Note that if the pump is required to lift water towards its inlet, the flooded suction takes a negative value and is referred to as 'suction lift'.
Flow	The quantity of water passing an observation point. For pumped liquids the term mass flow is often used and refers to the mass of liquid passing per unit time. However, it is more common to use volume flow, i.e. the volume passing per unit time.
Friction losses	Pressure losses caused purely by the resistance of the pipework and system, which must be added to static head to obtain the total system resistance. Note that friction losses vary with flow rate and that they occur in pump inlet pipework as well as outlet pipework.
Head	The pressure generated by a column of water. The pressure difference generated across a pump is usually quoted in terms of the equivalent height of water.
Impeller	The term used for the rotating part of a pump which imparts the rotodynamic motion to the pumped liquid.
Inverter	The most common type of variable speed drive where ac current is rectified to dc current, controlled then inverted back to ac current.
Multi-stage pumps	Pumps which contain several impellers, each feeding its output to the next stage in a serial fashion in order to generate pressures higher than a single-stage pump could achieve.
Neck rings	The rings attached to the casing which form a seal against the impeller between the high pressure and low pressure sections of a pump.
NPSH	Net Positive Suction Head: the total head at the pump inlet above vapour pressure. It usually has a subscript. $NPSH_R$ is the NPSH *required* by a pump at its inlet to prevent it from cavitating. $NPSH_A$ is the NPSH *available* from the inlet configuration in use. To avoid cavitation, therefore, $NPSH_A$ must be greater than $NPSH_R$.

Operating point	The point on a pump characteristic where the head/flow curve is crossed by the system resistance curve. This point will change if the pump performance changes (e.g. through wear) or if the system resistance changes (e.g. as a valve is opened or closed).
Power	Output from a motor is equal to the input power multiplied by the motor efficiency. It is this output power which is the power absorbed by a pump, i.e. the power value which features on pump characteristics.
Rated duty	The flow and head that are specified when obtaining a pump. These values appear on the pump nameplate. They should be close to the values corresponding to the peak efficiency of the pump.
Rotating element	The whole of the moving section within a pump casing. It includes the impeller, the shaft and the neck rings.
Seals	Prevent water leaking outwards along the pump shaft from the pump's low pressure section. They can be packed glands or mechanical seals.
Soft-start	The action of gently accelerating a motor from rest to full speed in order to reduce high starting currents and shock loadings. It allows an increase in the frequency of re-starting.
Static head	The head of water a pump must overcome before it will produce any flow and is a result of the height difference between the suction water level and delivery water level.
Throttling	Used to impose a restriction in a pumping system, often by means of a valve to control the flow through the system.
Two-stage pumps	Pumps using two impellers mounted on a common shaft with the outlet of the first feeding the inlet of the second. This series arrangement allows a two-stage pump to develop more pressure than a single-stage pump could achieve.
Vapour pressure	The pressure below which a liquid begins to form bubbles of vapour, and its value depends on temperature. The generation and collapse of such bubbles (similar to boiling) is usually termed cavitation.
Variable speed drive	A way of controlling the speed of a motor, usually electronically using an inverter. The speed can be varied manually, but is more often controlled via a signal from the process, e.g. pressure, flow, level, etc.
Velocity head	A measure of the kinetic energy possessed by some quantity of fluid in motion, in terms of the equivalent pressure of a column of water.
Yatesmeter	The name of the modern type of portable thermodynamic pump efficiency testing equipment developed by Advanced Energy Monitoring Systems (AEMS) and named after its inventor Maurice Yates.

APPENDIX 1

CAPITAL COSTS OF MOTOR INVERTER DRIVES (VSDS)

Information is given on the costs of ac inverter variable speed drives. The data have been collected from a variety of sources, including published papers and manufacturers' price lists. Most date from 1987 and 1988.

The data are presented in graphical form in Fig 26 (ac inverters). The costs for inverters are principally for the PWM type.

The price range figures quoted are for 'one off' purchases. Where an original equipment manufacturer is involved in buying motors and drives, substantial discounts may be negotiated. A potential user will be able to use his purchasing ability to undercut some of the unit prices.

The motors and drives industry is a highly competitive sector. Thus, competitive pricing may assist the buyer in obtaining a deal which will give a better payback than indicated by some of the figures listed.

In addition, equipment suppliers may be prepared to negotiate special arrangements. For instance, a company found one equipment supplier to be particularly helpful in setting up trials at a number of sites. Many units were offered on the basis of payment following demonstration of satisfactory performance.

Note: Data presented are for the capital cost of equipment only, i.e. installation is not included.

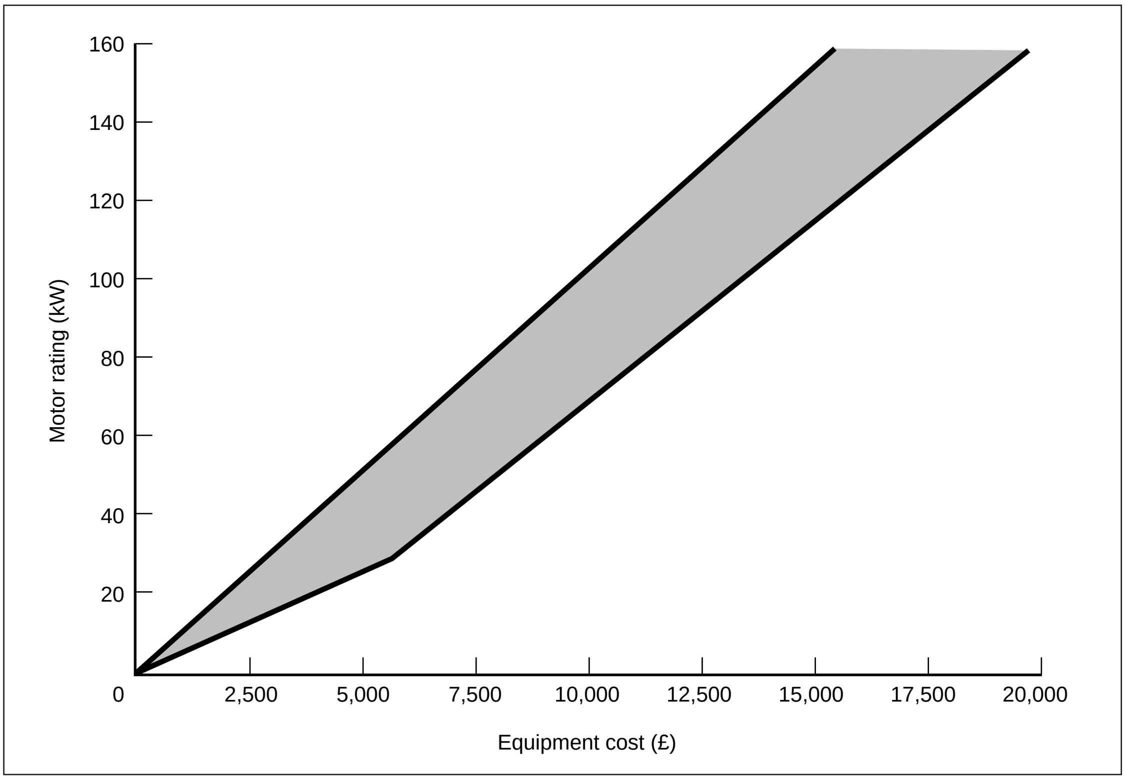

Fig 26 Equipment capital costs: inverters (VSDs)

APPENDIX 2

PUMP TYPES

A2.1 Pump Types

There are two main categories of pump defined by their basic principle of operation, namely *positive displacement* pumps and *rotodynamic pumps.* However, these are broad descriptions and both types can be sub-divided, as shown in Fig 27.

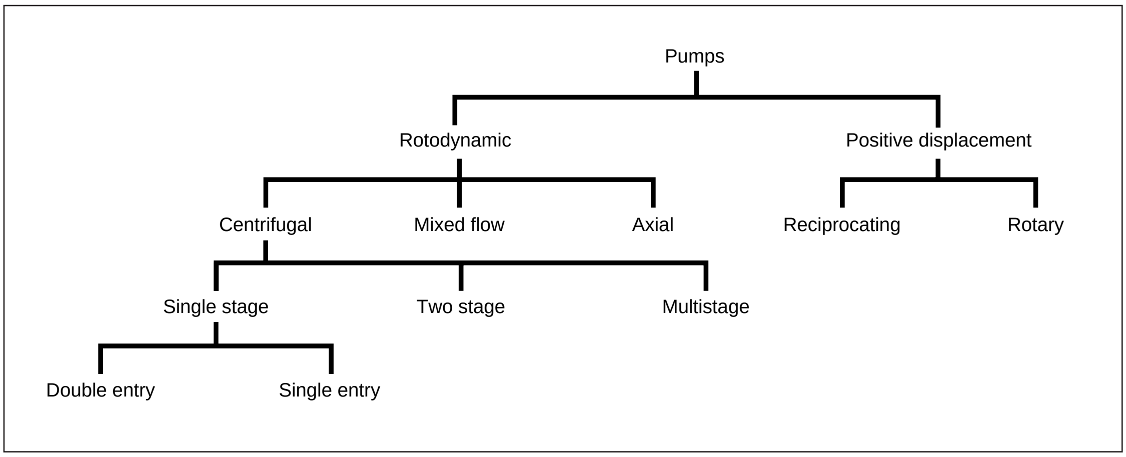

Fig 27 Pump types

Positive displacement pumps generate pressure hydrostatically by reciprocating or rotary action. Reciprocating machines tend to be confined to high-pressure, low-flow duties. Rotary machines are less suited to developing high pressure due to internal leakage and practical size restrictions. In general, positive displacement pumps are not suited to typical steel industry water pumping duties, although they are used extensively in hydraulic systems.

Rotodynamic pumps generate pressure hydrodynamically. They use impellers which displace fluid by momentum, rather than positive mechanical travel. They are well suited to the high volume requirements of typical steel industry processes, especially the centrifugal type. For the lower capacity end of the application range the single-stage, single-entry pump is adequate, but for larger duties the single-stage, double-entry type of pump is favoured as it can achieve a superior *efficiency*. Furthermore, the single-stage, double-entry type of design facilitates maintenance, as the top cover of a horizontal split-casing pump can be removed to reveal the entire *rotating element* without disconnecting the inlet and outlet pipe.

For pressures higher than can be generated by a single-stage centrifugal pump, a *two-stage pump* using two impellers can be used, although for very high pressure duties, e.g. descaling, the number of stages can be six, eight, or more. Pumps with more than two stages are usually referred to as multi-stage pumps.

The types of pump normally used for the range of water pump duties in steel industry processes are almost always centrifugal and horizontal split-casing for single-stage, double entry or two-stage machines. For multi-stage machines the casing is usually split radially. These types feature in the design specifications of many steel plants.

A2.2 Centrifugal Pump Operation

When describing a centrifugal pump it is simpler to consider initially a single-stage device. Two-stage and multi-stage pumps are essentially similar with the stages serially cascaded.

The illustration in Fig 28 shows a single-stage horizontal split-casing centrifugal pump with half its upper casing cut away to show the rotating element. As viewed, the inlet is to the left

and provides water to the outermost chambers at both sides of the pump. This type of pump is referred to as a double-entry design, as the water from these chambers enters the eyes of the impeller from both sides.

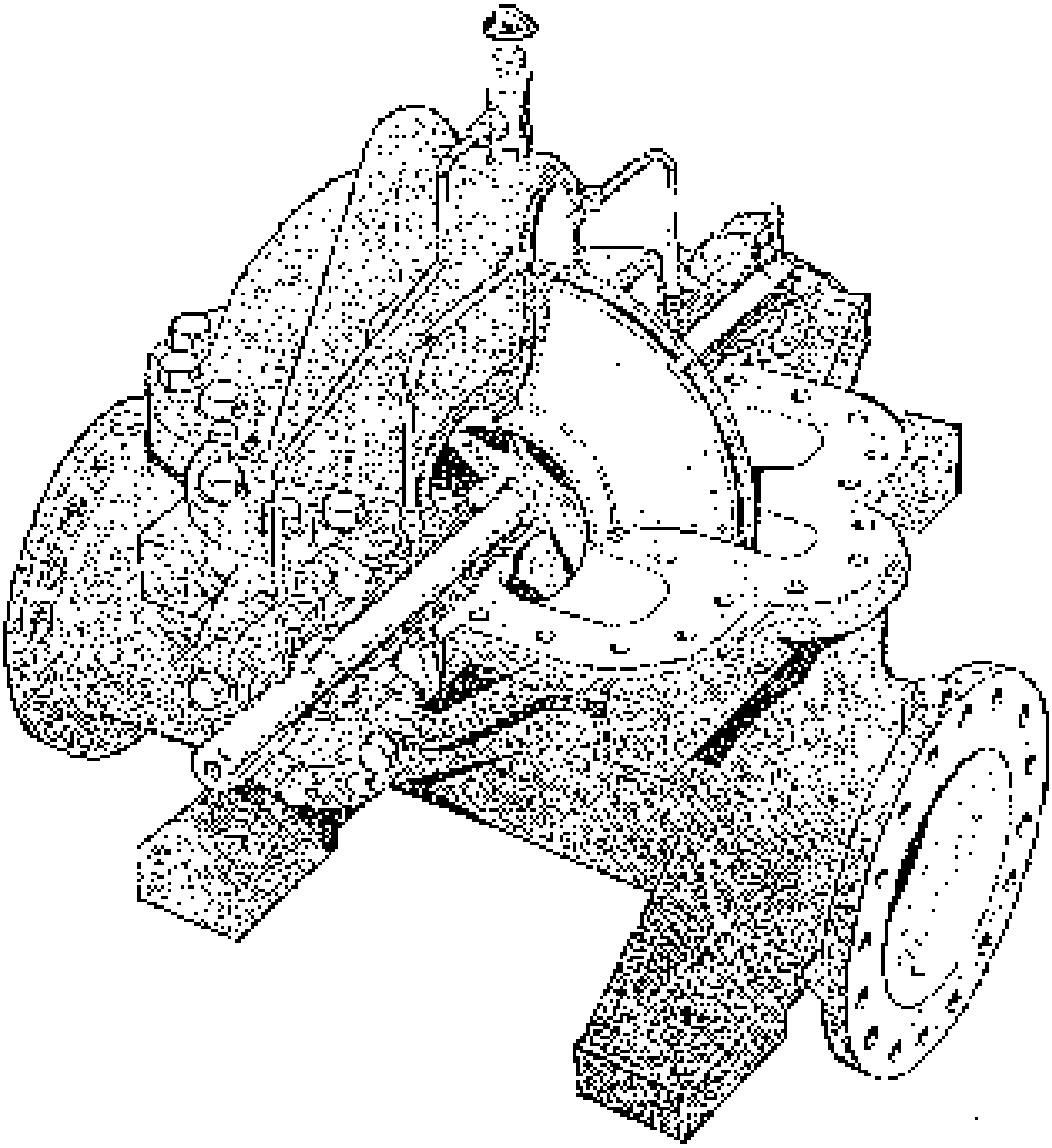

Fig 28 Single-stage double-entry split-casing pump

During rotation the internally vaned impeller throws the water towards its periphery to create a high pressure region, known as the volute, in the pump central chamber. The high pressure and low pressure chambers are separated by a neck-ring seal surrounding the impeller eye at each side. The volute is a spiral shape when viewed along the axis of the impeller, and forces water towards the pump outlet. Seals around the pump shaft prevent the leakage of low pressure water.

Fig 29 shows a two-stage axially split-casing pump with half of the upper casing removed.

The pump inlet towards the front only provides water to the right side of the right impeller (as viewed), which is the first stage. The outlet from the first volute leads over the top of the casing to the inlet chamber at the left of the second impeller. The outlet from this impeller forms the main pump outlet which is hidden from view at the rear.

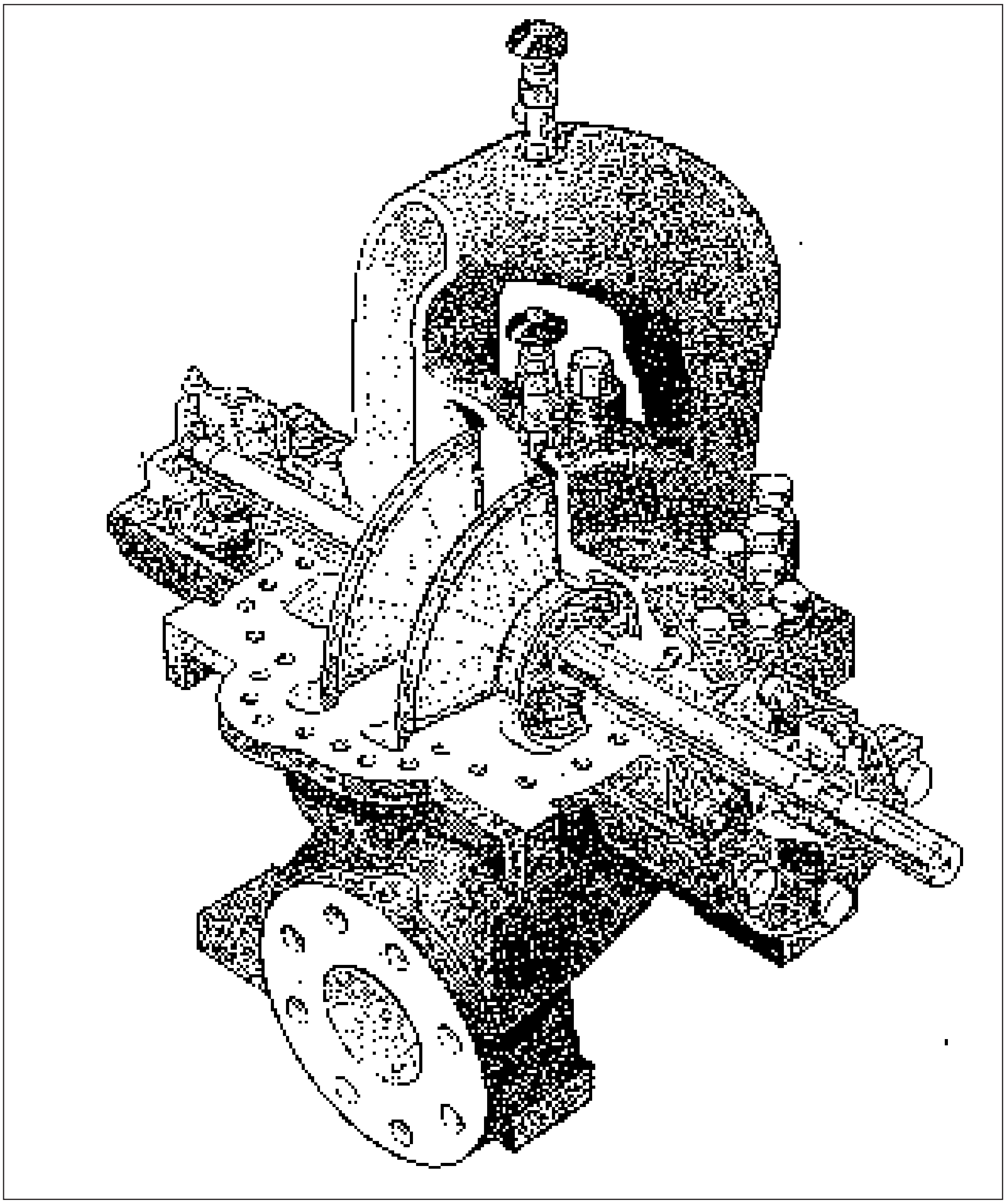

Fig 29 Two-stage axially split-casing pump

Fig 30 shows a multi-stage pump (5 in this case) with an upper quarter of the casing removed to show the impellers mounted on a common shaft. The inlet section (towards the front left of the diagram) delivers water to the eye of the first impeller. It is thrown into the first diffuser chamber, which directs the water through internal passages to the eye of the second impeller.

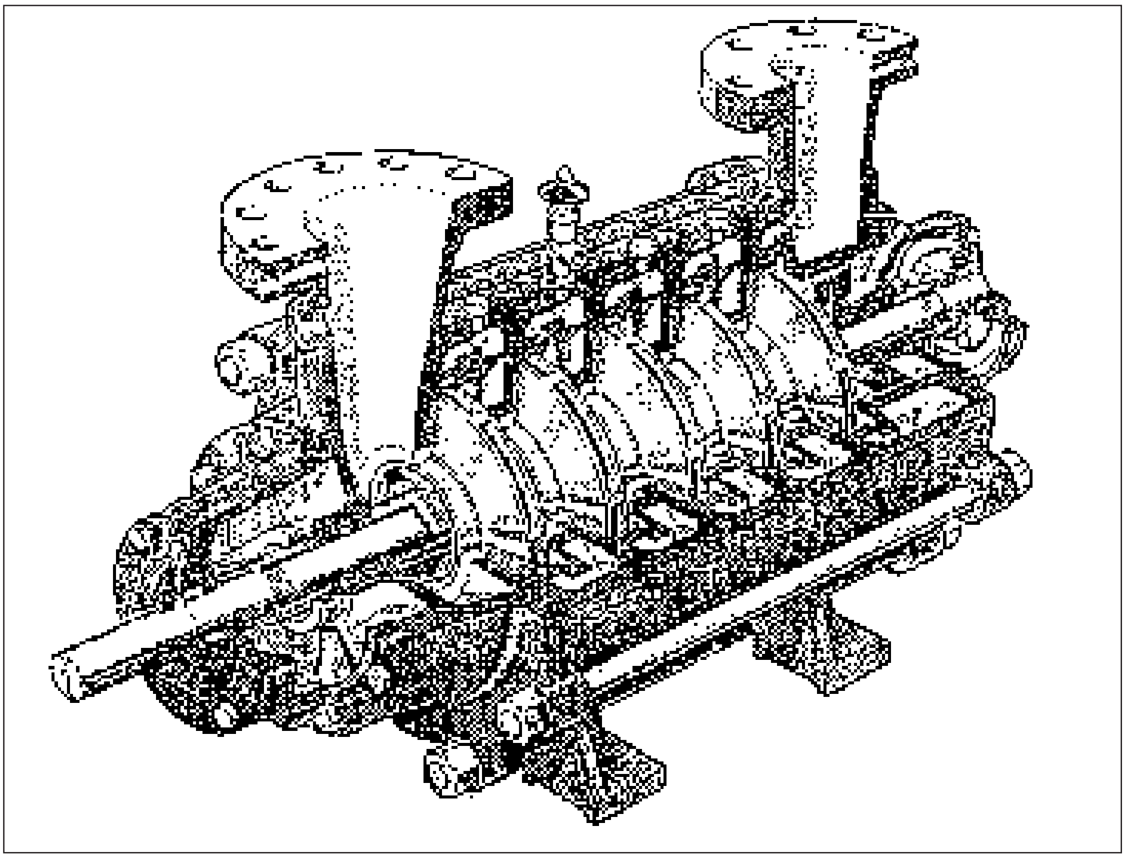

Fig 30 Centrifugal multi-stage pump

Successive stages operate identically until the final stage delivers high pressure water to the pump outlet.

A2.3 Pump Characteristic Curves

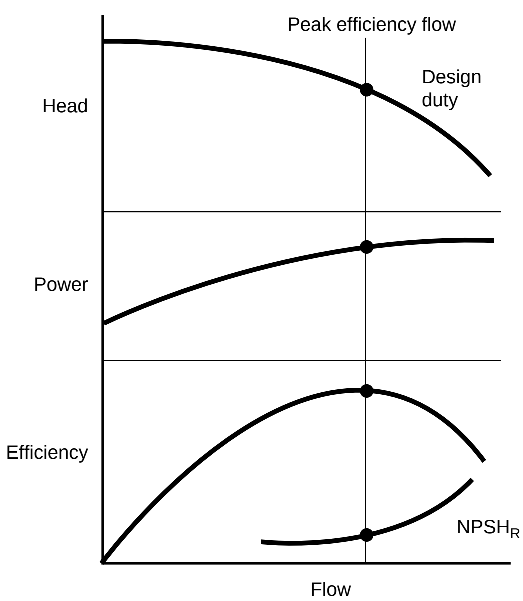

Fig 31 Centrifugal pump characteristics

These appear in a number of forms, the most common of these is shown in Fig 31. This is simply a graphical representation of how the three main operating parameters vary with flow.

It is important that these parameters and their interdependence are clearly understood. Proper system design leads to better performance and less maintenance and energy efficiency can be built into the design.

Head - the pressure difference generated across the pump, i.e. the gain in pressure between the pump inlet and pump outlet.

Power - the power absorbed by the pump, i.e. the shaft power required to generate the pressure and flow.

Efficiency - is the efficiency with which the shaft power, or power absorbed, is converted into pressure and flow.

Flow - the flow through the pump. Note that the peak efficiency flow is that corresponding with the maximum efficiency value and is often referred to as the *'design flow'* of the pump.

The above parameters are related by the following equation:

$$n = \frac{Qgh}{w} \times 100$$

where n = pump efficiency (%)
Q = mass flow (kg/s)
g = gravitational constant of 9.81 ms^{-2}
h = head generated (m)
w = power absorbed (w)

Note that for water, where the specific gravity is 1.00, the mass flow in kg/s is equivalent to the volumetric flow in litres/s. Head is expressed in metres and is equivalent to the pressure generated by a column of water of that height.

Also shown on the characteristics is a curve labelled $NPSH_R$, or 'net positive suction head required'. The curve represents the minimum total head above vapour pressure required at the pump inlet (suction) to prevent cavitation from reducing the generated head (or pressure difference). To satisfy this condition it is necessary for the inlet pressure, or $NPSH_A$ (net positive suction head available), to exceed the $NPSH_R$. $NPSH_A$ can be represented as the arithmetic sum of all the factors contributing to the NPSH at the pump inlet, as shown in Fig 32.

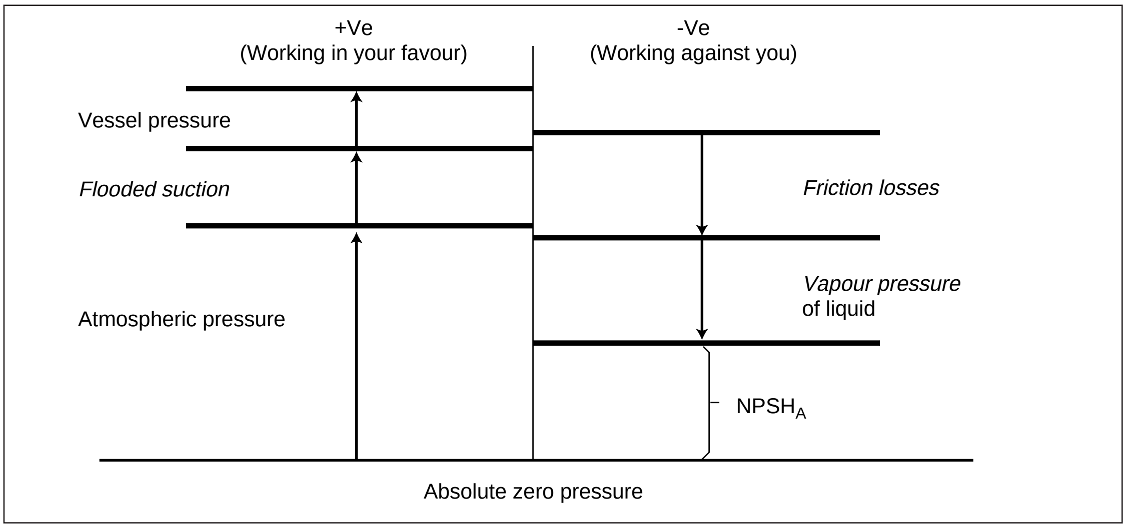

Fig 32 Illustration of $NPSH_A$

The important features of the $NPSH_R$ curve are:

- it increases at flows greater than the peak efficiency flow, making cavitation more difficult to avoid at high flows;
- it is usually extended in the low flow direction to flows of around $^1/_3$ (very approx) of the peak efficiency flow. At lower flows the curve can exhibit a dramatic upturn caused by the onset of low flow cavitation.

Cavitation, besides reducing the generated head, can damage the internal pump surfaces and should be avoided. It is usually accompanied by an easily recognisable rattling sound. The head/flow curve in Fig 33 illustrates the onset of this and other events which can adversely affect pump performance when operating at flows well away from the peak efficiency flow.

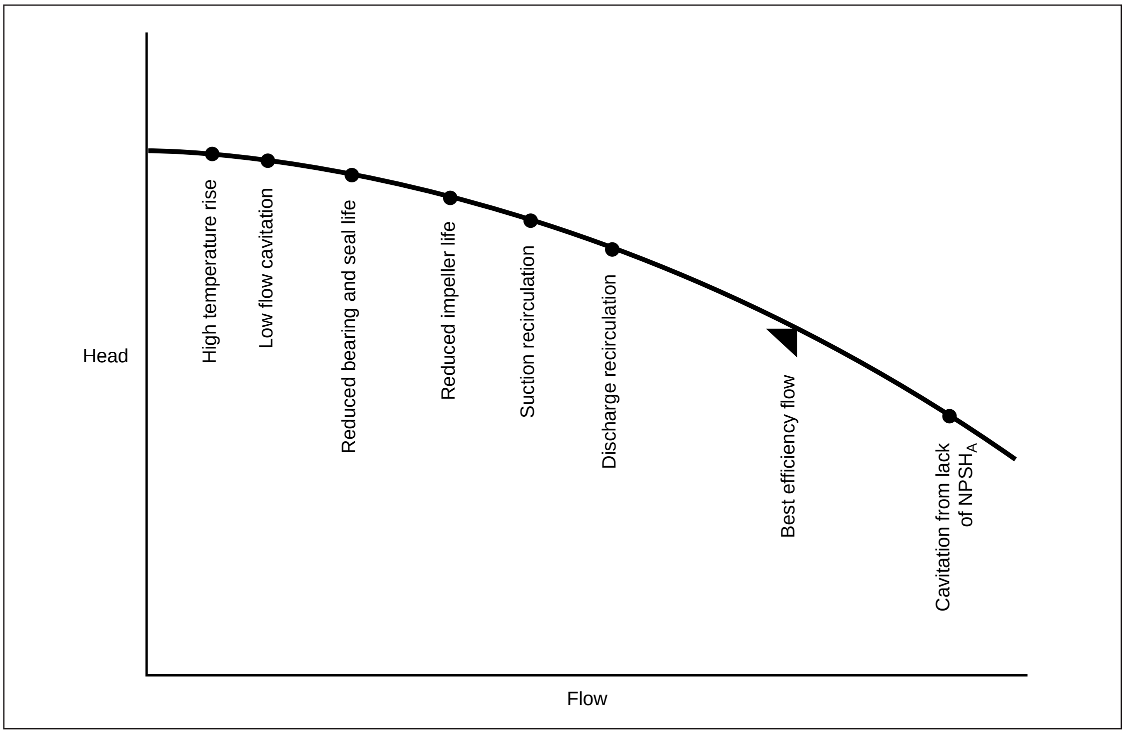

Fig 33 Onset of adverse effects when operating a pump away from its peak efficiency flow

Clearly it is important to try and arrange for pumps to operate at or around the peak efficiency flow for effective and efficient operation.

A2.4 Pump Combinations

A2.4.1 *Series Combinations*

If the outlet of one pump is connected to the inlet of a second pump, then a combined head/flow characteristic is obtained by adding the heads at each flow value, as illustrated in Fig 34.

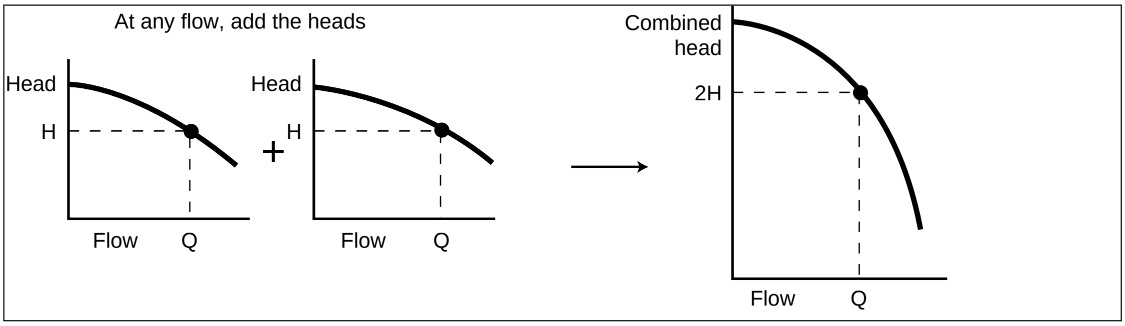

Fig 34 Combined characteristics of pumps connected in series

This is consistent with the fact that the head developed by a pump is the gain in pressure between its inlet and outlet. It is also the principle by which two-stage and multi-stage pumps operate to generate high pressures. Another common application of the principle is where a booster pump is used to generate a high pressure water supply from a low pressure feed. The combined curve for any two (or more) pumps can be obtained in this way, even if they are dissimilar. The combination will always produce a head and flow according to this curve. However, the addition of a pump in series does not necessarily add that pump's full pressure capability to the total generated. The total head (and flow) produced is governed by the system the pumps are connected to.

A2.4.2 *Parallel Combinations*

If two pumps are linked in parallel so that their inputs feed from a common main and their outputs lead to a common main, then the combined characteristic can be obtained by adding the flows at each head value, as illustrated in Fig 35. This technique holds for any two (or more) pumps, even if they are dissimilar. Adding an extra pump in parallel does not necessarily add that pump's full flow capability to the total produced (see Section 4.10).

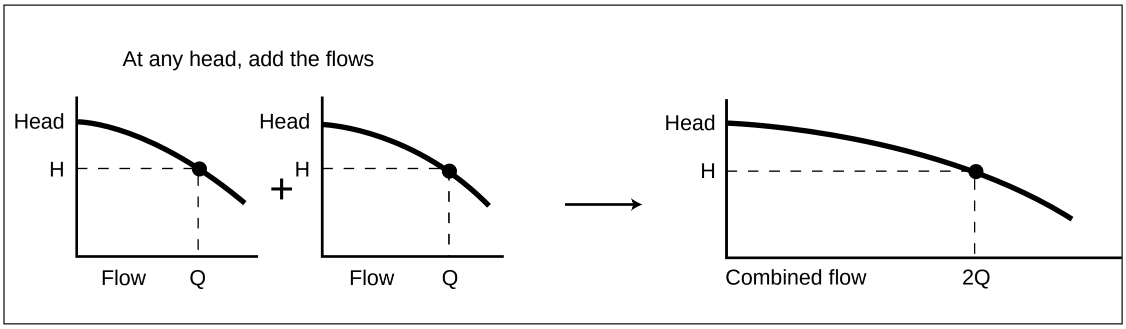

Fig 35 Combined characteristics of pumps connected in parallel

A2.5 Connecting Pumps to Pipework Systems

Delivering water to its destination requires some form of pipework system. To drive the water through the pipe, the pressure generated at the pump discharge is required to overcome the resistance of the pipework and system, and to raise the water through any height difference between suction water level and delivery water level. If there is no height difference, the system resistance is purely frictional and the flow that can be driven through the pipework will vary with applied pressure from the pump according to a square law, as shown in Fig 36.

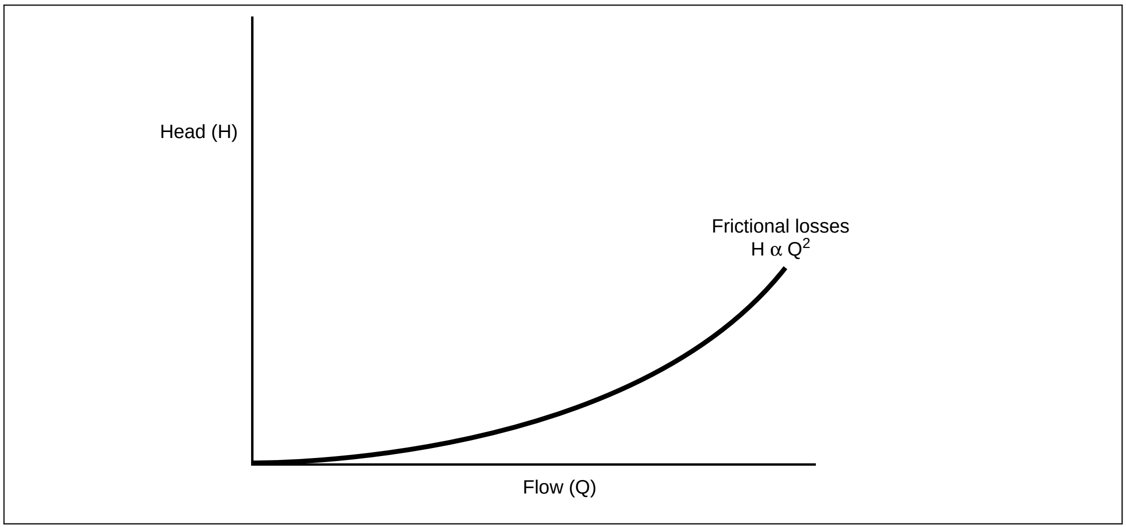

Fig 36 System resistance for frictional losses only

For most systems there will be some height difference between pump suction and delivery water levels. The pump will not deliver any flow until it has developed sufficient pressure to overcome the pressure due to that height of water, i.e. the static head. Effectively, the two components are added and the combined system resistance is as shown in Fig 37.

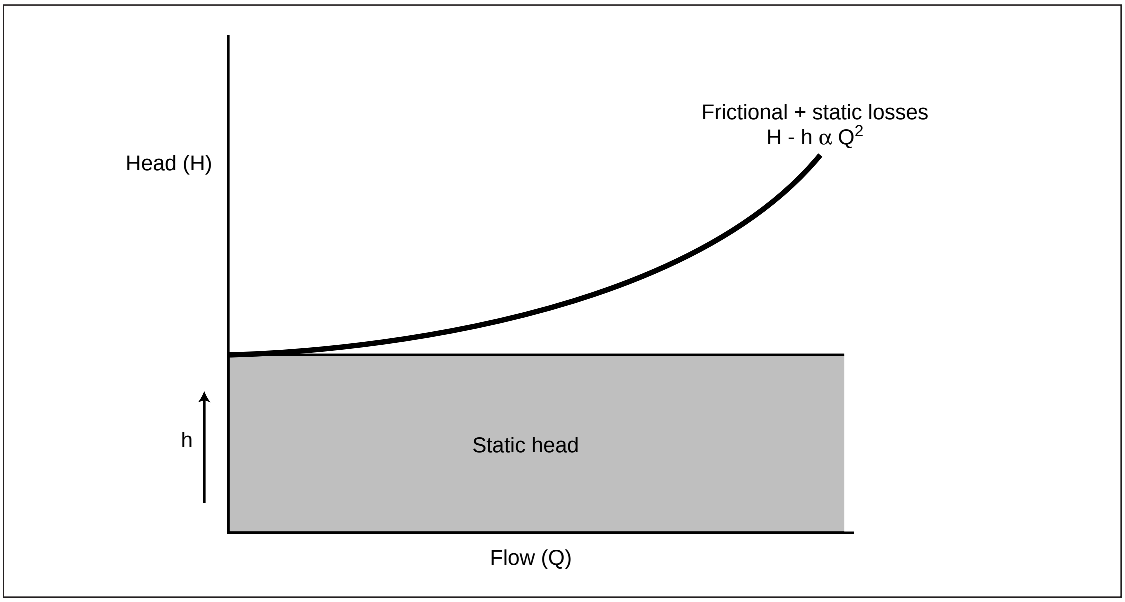

Fig 37 Total system resistance from frictional losses plus static head losses

The shape of the curve due to frictional resistance is dictated by factors such as the pipework diameter and its internal roughness, the number of bends and their curvature, and the degree of closure of any valves. An increase in system resistance caused by partially closing a valve in the delivery pipework would tend to increase the steepness of the curve.

A2.6 Operating Point

A pump (or combination of pumps) can only operate at pressures and flows according to its head/flow characteristic, similarly the system it connects to can only deliver water according to its system resistance curve. Therefore, the actual operating point can be found by superimposing the two characteristics, as in Fig 38.

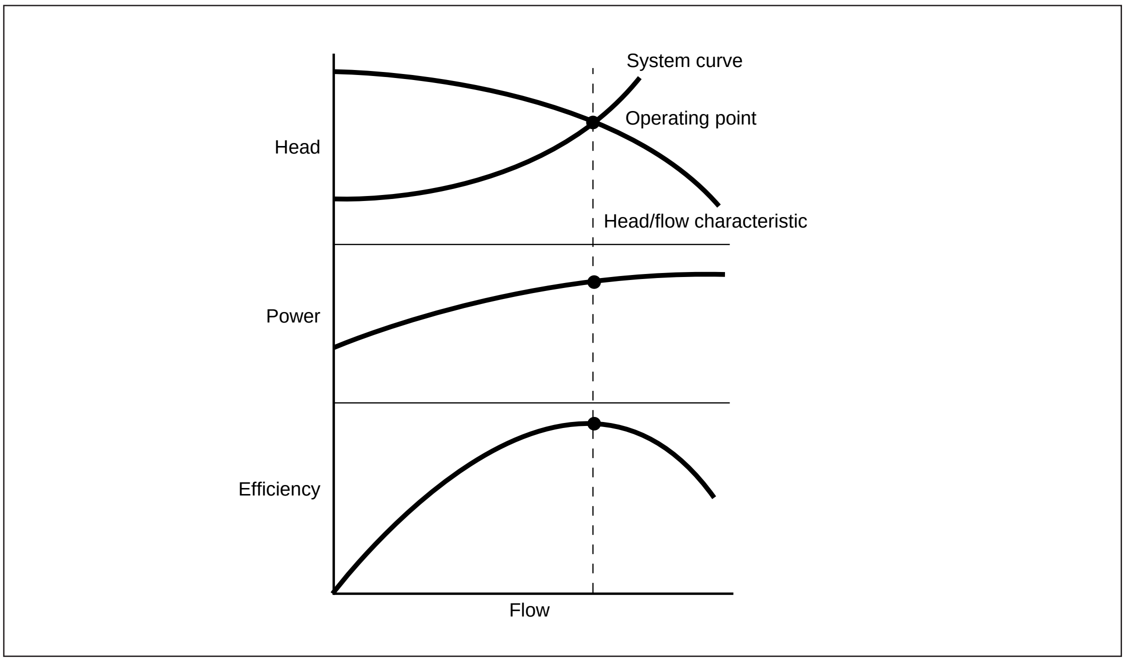

Fig 38 System resistance superimposed on pump characteristics

If the system resistance remains unchanged the pump will deliver the same flow, as shown by the point where the system resistance curve crosses the head/flow curve. The power absorbed and the pump efficiency at this flow are at points on the relevant curves vertically below the operating point. Ideally, the system resistance results in pump operation at, or close to the peak efficiency flow.

A2.7 Pump Name Plates

Every new pump has a nameplate fitted to it. This shows details of the pump inlet and outlet flange size but more importantly, it shows head and flow values which the pump should achieve, i.e. its rated duty. Note that these figures are matched with figures specified by the purchaser and might not correspond with the peak efficiency flow. The pump will be chosen by the manufacturer as the one whose performance is nearest to the requested specification. Usually, pumps can be matched so that they are capable of achieving an efficiency reasonably close to the peak value.

A2.8 New Pump Performance Tests

New pumps perform to a set of generic characteristics which can be confirmed if a test is requested on a particular pump. British Standard BS5316 gives a guaranteed acceptance limit for any pump test, although the limit varies depending on the classification of test standard. For a Class C test, the lowest classification, and also the standard by which most steel industry pumps are tested when bought, the following must be true:

at the guarantee point, i.e. the rated duty according to the nameplate, the test curve must pass through an ellipse based on a ±4% head variation and a ±7% flow variation, as illustrated in Fig 39;

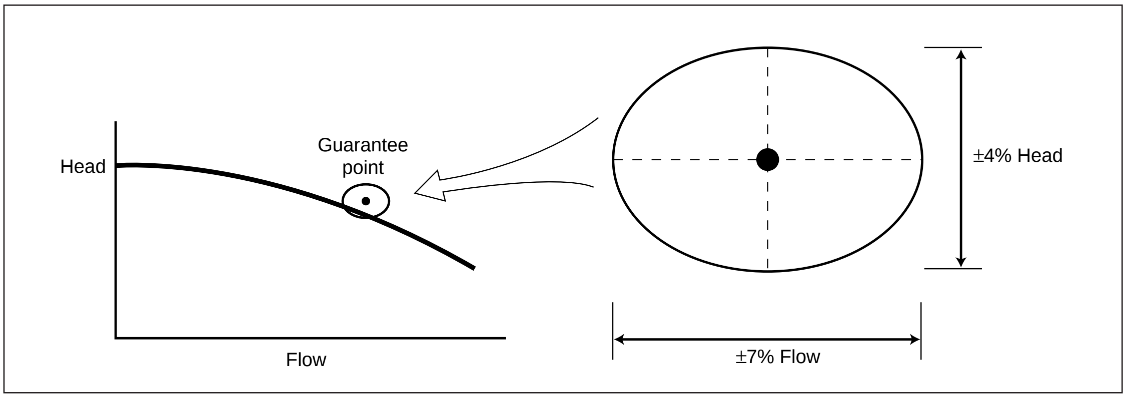

Fig 39 Illustration of the permissible margin on a Class C test guarantee point

also, the pump test efficiency must be at least 95% of that stated at the guarantee point. Hence, a pump tested to Class C standard could show a test efficiency up to 5% less than expected.

Class B standard tests offer a tightening of these limits, but add to the price of a new pump.

A2.9 Summary of Potential Problems

From this brief look at some of the principles of pumping it is clear that there are a number of important features of pumps and their operation that should be considered if costs are to be reduced. These include:

- if the $NPSH_A$ (or pump inlet pressure) is insufficient then pump performance can be adversely affected and efficiency will be reduced;

- cavitation should be avoided. It can dramatically affect pump performance and efficiency, and can also cause permanent pump damage;

- operating pumps away from their peak efficiency flow not only reduces pumping efficiency but can invite other adverse effects;

- the duty point shown on pump characteristics is that specified by the purchaser and might not correspond with the peak efficiency flow;

- pumps tested to Class C could show a test efficiency up to 5% less than might be expected from generic pump characteristics;

- running costs form the major part of lifetime costs. Therefore it is important to keep efficiency high to save running costs;

- a 100 kW pump can cost between £20,000 and £30,000/year to run.

APPENDIX 3

USEFUL CONTACTS

A list of contacts for products and services is given below. The list is not exhaustive and has been compiled from information currently available to the Energy Efficicency Best Practice programme. The listing of an organisation should not be regarded as an endorsement of its services or products by the programme. Similarly the programme makes no claim for the competence or otherwise of any organisation not listed.

Pump Coatings Suppliers

Belzona Ltd
Claro Road
Harrogate HG1 4AY
Tel No: 01423 567641

Weir Engineering Services
149 Newlands Road
Cathcart
Glasgow G44 4EX
Tel No: 0141 637 7141

Corrocoat Ltd
Forster Street
Leeds LS10 1PW
Tel No: 01532 760760

Advice on Pumping

The Pump Centre
Building RD1
AEA Technology
Birchwood Science Park
Warrington WA3 6AT
Tel No: 01925 252185

Pump Sales
Lists of equipment suppliers are published in the trade journals and by trade associations.

British Pump Manufacturers' Association
Bridge House
Smallbrook Queensway
Birmingham B5 4JP

Weir Pumps Ltd
149 Newlands Road
Cathcart
Glasgow G44 4EX
Tel No: 0141 637 7141

Ingersoll Dresser Ltd
P.O. Box 17
Lowfield Works
Newark NG24 3EN
Tel No: 01636 705151

Motor and Drive Manufacturers and Suppliers

Lists of equipment suppliers are published in the trade journals and by trade associations. The GAMBICA Association publishes a list of suppliers of Electronic Variable Speed Drive Systems and a list of suppliers of Electronic Soft Start Motor Control Systems.

The GAMBICA Association Limited
Westminster Tower
3 Albert Embankment
London SE1
Tel No: 0171 793 3000
Fax No: 0171 793 3003

Pump Efficiency Testing

British Steel plc
Swinden Laboratories
Moorgate
Rotherham
South Yorkshire
S60 3AR
Tel No: 01709 820166

Advanced Energy Monitoring Systems Limited
The Energy Centre
Finnemore Industrial Estate
Ottery St. Mary
Devon
EX11 1NR
Tel No: 01404 812294

The Government's Energy Efficiency Best Practice Programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry, transport and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice Programme are shown opposite.

Further information

For buildings-related publications please contact:
Enquiries Bureau
BRECSU
Building Research Establishment
Garston, Watford, WD2 7JR
Tel 01923 664258
Fax 01923 664787
E-mail brecsuenq@bre.co.uk

For industrial and transport publications please contact:
Energy Efficiency Enquiries Bureau
ETSU
Harwell, Didcot, Oxfordshire,
OX11 0RA
Fax 01235 433066
Helpline Tel 0800 585794
Helpline E-mail etbppenvhelp@aeat.co.uk

Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R & D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Energy Efficiency in Buildings: helps new energy managers understand the use and costs of heating, lighting etc.